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CONTENTS

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NORTHWARD FALL MIGRATION ON THE ATLANTIC COAST AND ITS RELATION TO OFFSHORE DRIFT

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Although the study of migration on islands has many advantages, interpretation of the results usually requires a detailed understanding of the way in which weather changes affect migrating birds. Such migration is often highly erratic, strongly correlated with the occurrence of winds blowing from the mainland, and characterized by a high incidence of species outside their normal range. These facts have been used at times to argue that the islands concerned lie off the main routes of migration, and that the birds reaching them should be classified as windblown vagrants. On the other hand, birds often reach outlying islands so regularly and in such large numbers that such an explanation is difficult to accept without more detailed investigation.

In describing investigations of migration on the island of Nantucket off southeast Massachusetts, Dennis and Whittles (1955, 1956) have called attention to a remarkably intense daytime migration that takes place there regularly each fall. The birds involved in this movement, consisting largely of species normally considered to be nocturnal migrants, pass rapidly through the island and leave in a northwest direction toward the mainland. Seventy-five miles to the west, on Block Island off the coast of Rhode Island, we encountered a closely similar northwestward migration in the falls of 1957 and 1958, and there is circumstantial evidence that analogous movements occur at many other places along the Atlantic coast of North America. This paper reviews the many scattered references to this singular phenomenon and discusses its significance in relation to studies of the migration along the Atlantic coast, which has received much attention in recent years (Baird, Robbins, Bagg, and Dennis, 1958; Baird, Bagg, Nisbet, and Robbins, 1959).

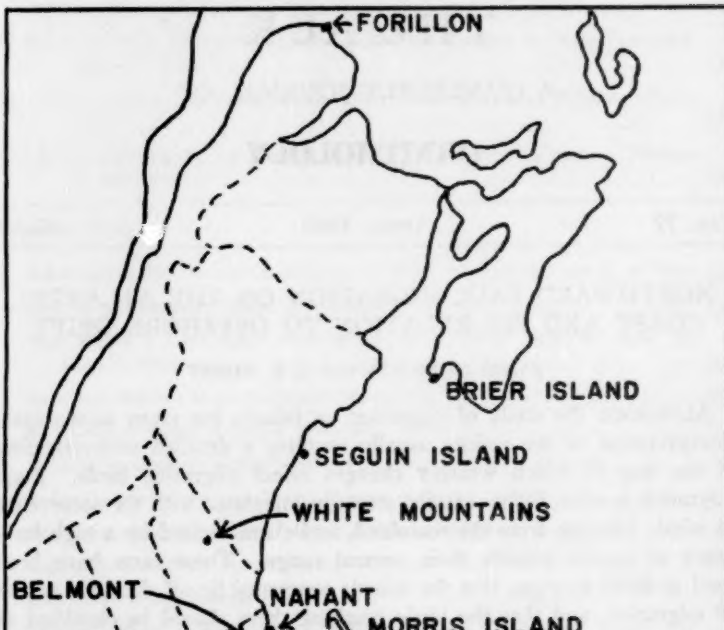

Figure 1. Places mentioned in the text.

It is necessary to distinguish between *diurnal migrants, i.e.,* species whose migration normally takes place largely in daylight hours, and *daytime migration,* the movement of any species in the daytime. In fact, this paper is concerned primarily with the unusual phenomenon of daytime migration of species that are primarily nocturnal migrants. Difficulties of interpretation arise over a few species whose migration may take place either by day or by night (*e.g.,* in our experience, the Robin, Bobolink, and Yellow-shafted Flicker); these species have usually been included in the descriptions of the observed movements, but little consideration has been given them in the discussion.

Field Observations

Nantucket, Massachusetts (Figure 2)

Daily observations (Dennis and Whittles, 1955, 1956) at the Mothball Pines, a small, planted grove close to the southern shore of the island, have shown that many flycatchers, vireos, warblers, sparrows, and certain other nocturnal migrants continually pass through in small groups, descending into the trees and stopping to rest and feed for periods of up to an hour before departing west-northwest. The same species also occur in thickets in the northern part of the island, but

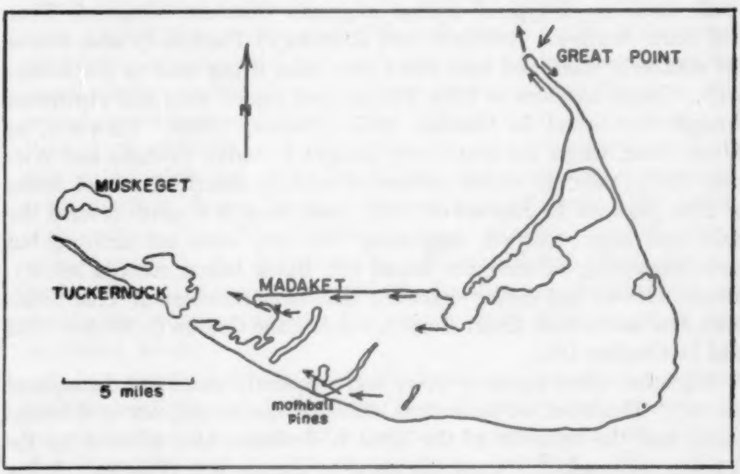

Figure 2. Map of Nantucket Island, Massachusetts. The arrows denote observed directions of migration (for details see the text, and Dennis and Whittles, 1955, 1956).

here other species, notably Catbird,[1] Brown Thrasher, Rufous-sided Towhee, etc., which rarely occur on the south coast, are also numerous. Both groups occur at Madaket, where also many birds descend for short periods before setting out to the northwest over the small islands of Tuckernuck and Muskeget. On the island, the birds characteristically ascend steeply on departure, and climb steadily until out of sight.

Warblers are also seen at Great Point, and Dennis and Whittles (1955) concluded that they arrived from the north (probably from Monomoy, the southern extremity of Cape Cod, 10 miles to the north), and drew hypothetical routes extending south and west through the island. A southerly route, close to the east and south shores, was thought to be used chiefly by warblers and sparrows (further details of the species found here may be found in the tables in Dennis and Whittles, 1955, 1956), and a northerly route through the northern part of the island was cited for other land birds. Subsequent observation, however (Dennis, pers. comm.), has suggested that these routes are not so well defined as was thought in 1955; many birds descend into the thickets from high altitudes, and it is now thought possible that many birds stop at only one place on the island. Recoveries of banded birds, however, show that at least some birds move west from place to place within the island (Baird *et al.*, 1958).

In addition to the movements of the nocturnal migrants, relatively small numbers of typical diurnal migrants (Eastern Kingbird, Tree and Barn swallows, Bobolink, and Redwinged Blackbird) also follow the southerly route and have often been seen flying west at the Mothballs. Large numbers of Pine Siskins also passed west and northwest through the island in October 1957 (Dennis, 1958). However, at Great Point, where the birds were thought to arrive (Dennis and Wittles, 1955), the only visible movement actually described was of flocks of Blue Jays on 30 September 1955; and these flew north toward the point and later returned, suggesting that they were not arriving but were attempting to leave the island (cf. Block Island records below). Meade (1944) had earlier described how large numbers of Tree Swallows flew north from Great Point towards Cape Cod on 6 October 1942 and 11 October 1943.

Migration often starts at dawn and frequently continues throughout the day. However, on some days, different species migrate at different times, and the behavior of the birds is doubtless also affected by the weather, although this is not discussed by Dennis and Whittles. A few individuals sometimes remain in the thickets all day, while others may

[1] Scientific names of species mentioned in the text are given in an Appendix.

linger "off-passage" in the same area for periods varying from a few days to several weeks (Baird *et al.*, 1958).

In discussing the species composition of the migrants at the Mothballs, Dennis and Whittles (1955) pointed out the relative scarcity of typical diurnal migrants, of species that prefer brushland and open-field habitats (which occur in numbers in other parts of the island), and of a few other nocturnal migrants, notably the Eastern Phoebe, House and Long-billed Marsh wrens, and Chipping and Field sparrows. Subsequent observation (Dennis, *in litt.*) has shown that all these species except the House Wren occur in numbers elsewhere on the island. With this one exception, the species recorded on Nantucket seem to be a fair sample of the nocturnal migrants that occur on the adjacent mainland, although a few species such as the Cape May and Bay-breasted warblers appear to be relatively more numerous on the island.

Block Island, Rhode Island (Figure 3)

Like Nantucket, Block Island has long been known for its remarkable concentrations of passerine migrants; during regular October visits made there in the last 10 years, members of the Audubon Society of Rhode Island have invariably encountered impressive numbers of birds. Baird first visited the island in 1956 with this group, and was immediately successful in netting over 200 birds, including 60 White-crowned Sparrows and nearly 100 Savannah Sparrows, in less than 50 net hours—a far larger number than could have been caught in the same netting period on the mainland. In October 1957, he again encountered a large "wave" of migrants, and noted that the main concentration of birds was at the north end of the island, and that some species departed in large numbers during the morning and flew off toward the mainland eight miles away. The northward movement was resumed after the wind dropped in the early evening, when Baird and others saw a few birds crossing the moon in a northerly direction; a similar casual watch during the previous evening had shown birds going south in strong northwest winds.

It was noted on this visit that the departing birds were concentrated over the northern tip of the island (A on Figure 3), and we were subsequently informed by some fishermen who regularly work this point that they had often seen small birds leaving in this way. This suggested that this northward movement is a frequent phenomenon at Block Island, and we made a special effort to study it during our most recent visit, from 11 to 13 October 1958. The details are given in full since

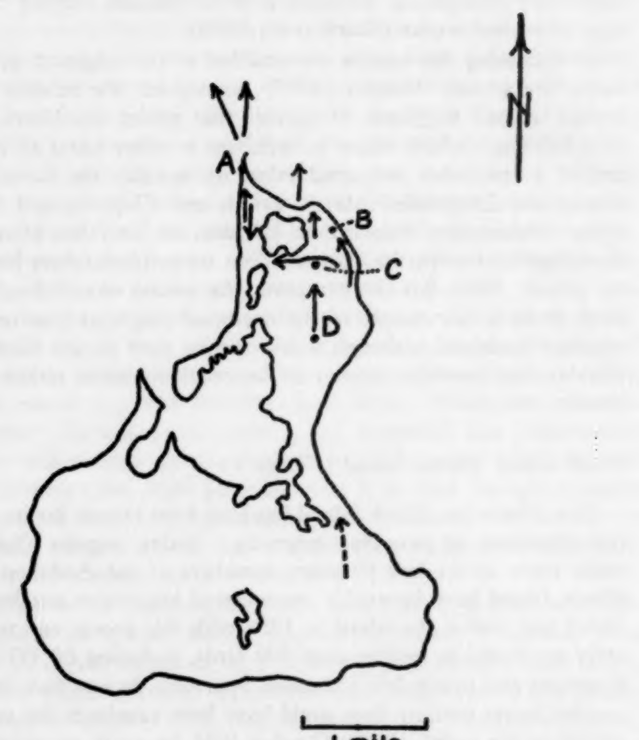

Figure 3. Map of Block Island, Rhode Island. The solid arrows indicate the directions in which night migrants were seen flying during the authors' visits in October 1957 and 1958. The dashed arrow denotes an observation of birds flying north across the face of the moon in 1957. A, B, C, D are the observation points mentioned in the text.

they illustrate points that were not covered in the accounts of the movements at other places (see points 7, 8, and 9 on page 133).

A cold front that passed during the night of 10/11 October was succeeded by an unusually strong flow of polar air, strong northwest winds persisting until the afternoon of the 13th. Perhaps for this reason (see Baird *et al.,* 1959), an exceptional wave of migrants reached the island, building up to a large peak on the morning of the 13th, when Myrtle Warblers, Slate-colored Juncos, and sparrows were present in hundreds or thousands wherever we went in the northern half of the

island. A much smaller, but still large, influx had occurred on the previous morning, but comparatively few migrants had arrived on the 11th. Because of this progressive build-up in the numbers of birds on the island, we can be sure that most of the birds seen migrating on the 12th and 13th had only just arrived.

The first sign of movement was seen on the morning of 12 October, in clear weather with the wind northwest at about 30 m.p.h. Watching at point A between 0700 and 0815, we saw only a single flock of eight Common Grackles, which flew north to the point six times, but returned on each occasion. A few birds were also noted working north to the cliffs at B, but were likewise forced to return by the strong headwinds. However, about 0830, the wind dropped slightly, and in the next 1½ hours, large numbers of birds (including Myrtle Warblers, Slate-colored Juncos, and Chipping Sparrows, in numbers between 100 and 300) were seen flying north from bush to bush through the gardens and brushy moorland around points C and D. By 1100, although none had been seen to return down the island, most of these birds had disappeared from the north end, and we believe that many had continued north to the mainland. However, substantial numbers of birds remained in other parts of the island throughout the day, and the only subsequent visible movement was that of a flock of 300 Tree Swallows, which passed north over C at 1600, and also appeared to continue northward over the sea.

Next morning (13 October), the wind was still blowing from the northwest at speeds varying between 15 and 25 m.p.h., the sky remaining clear until about 1030, when a heavy cloud bank began to build up over the mainland. Northward movement began soon after dawn, and until about midday, large numbers of birds were seen leaving the island at point A and flying north or northwest toward the mainland. Some birds turned on reaching the point and returned down the island, but most continued purposefully over the sea, and a small proportion was watched flying a steady northward course until out of sight. Table 1 summarizes counts made there between 0650 and 1135, and shows that only a few species departed in large numbers, the peak movements of each being at different times. In contrast to the observations reported from Nantucket, only a few species (*e.g.,* Myrtle Warbler and Savannah Sparrow) rose to a high altitude on departure: Eastern Meadowlarks and Yellow-shafted Flickers flew steadily at 100 to 300 feet, Slate-colored Juncos were flying at less than 100 feet, while Eastern Phoebes and Brown Creepers flew only a few feet above the waves.

The birds seen at A approached along both shores of the point, while early in the morning (0650–0730) another observer had seen many

TABLE 1

COUNTS OF BIRDS (GROUPED IN HALF-HOUR PERIODS) LEAVING THE NORTHWEST POINT OF BLOCK ISLAND, RHODE ISLAND, ON 13 OCTOBER 1958

	Time (E.S.T.)									
Species	0650 0730	0730 0800	0800 0830	0830 0900	0900 0930	0930 1000	1000 1030	1030 1100	1100 1130	*Total*
Yellow-shafted Flicker	34	2	88	24	46	197	119	105	48	600 (63)*
Brown Creeper	1	4	1	2	4	22	5	8	8	42 (13)
Water Pipit	22	27	—	3	—	—	3	1	—	20 (36)
Cedar Waxwing	—	—	—	—	2	—	24	27	—	51 (2)
Myrtle Warbler[1]	1	6	11	133	241	80	43	37	73	607 (8)
Blackbirds[2]	53	240	33	1	4	—	—	3	1	11 (324)
Eastern Meadowlark	17	—	24	—	8	6	3	—	—	28 (30)
Slate-colored Junco	1	9	61	63	117	283	361	485	311	1635 (56)
Savannah Sparrow[3]	8	35	149	180	143	67	83	53	6	721 (3)
Others (21 species)	1	3	8	9	26	14	2	5	10	48 (30)

* totals in parentheses are of birds that reached the point and returned southwards.

[1] Perhaps including a few other warbler species.

[2] Mainly Redwinged and Rusty Blackbirds.

[3] Possibly including a few other sparrow species.

Brown Creepers, Yellow-shafted Flickers, and other species migrating at point B, many arriving from the south and after some hesitation turning along the coast toward A. Later in the morning, however, large numbers of birds left northward from this point. Many birds of the same species were also seen flying north at C, while in addition, several other species were seen there in large numbers without appearing at A—*e.g.,* a flock of several hundred Tree Swallows, which turned west at B, and similar numbers of Robins, Eastern Meadowlarks, and Cedar Waxwings, which were first seen over the cliffs to the east and which flew west over C toward the west side of the island. Other species (notably White-throated and Chipping sparrows) steadily worked their way north through the bushes and accumulated in large numbers at C during the morning, while netting at C revealed several other species moving through at different times. Close examination of these captured birds showed that none had more than a little subcutaneous fat.

The numbers of birds that left the island were only a fraction of those present, and large numbers still remained on the island when the movement was over. Indeed, some species (Hermit Thrush, Rufous-sided Towhee, White-throated, White-crowned, and Chipping sparrows), although taking part in the northward migration through the island, were not seen to leave at all. It is possible that some of these species were deterred from leaving by the strong headwinds, as suggested by the observations on the previous day.

Other Places on the Atlantic Coast (Figure 1)

No systematic observations of migration have yet been made on Martha's Vineyard, Massachusetts, the only other island off the New England coast comparable in size to Block Island and Nantucket. However, the scattered observations summarized below on migration on smaller islands, and at places along the coast of the mainland, show that a northward or northwestward movement of nocturnal migrants during daylight hours is a common feature of autumn migration along the Atlantic seaboard from Virginia to the Gulf of St. Lawrence.

The following list summarizes the best-documented observations made of such movements. In addition to these, more or less casual observations of south or southwest movements in coastal districts have been given by Allen (1903), Anon. (1953a,b) and Brewster (1886), and at Belmont, Massachusetts, a short distance away from the coast (Robbins, *in litt.*). Northward movements have also been seen inland within 100 miles of the coast, in the White Mountains of New Hampshire (Allen, 1903), at Dover, Massachusetts (Bagg *in litt.*), and at Mt. Tom, Massachusetts, and Hartford, Connecticut (Bagg, 1950). However, at the last three places, southward movements have also been observed, and the situation is too complex to review without more observation.

Cape Charles, Virginia. The passerine migration here in the fall of 1936 was described briefly by Rusling (1937), and appears to be closely similar to that at Cape May, New Jersey, which has been studied in greater detail (see below). The largest numbers of birds were seen on days of north and northeast winds, when most flew south down the seaward side of the peninsula, turned on reaching the Cape and departed northward up the west shore. The numbers were often large, the highest day's counts being 3,155 Yellow-shafted Flickers, 5,000 Tree Swallows, 10,325 Robins, and 1,600 Myrtle Warblers. No flickers were ever seen to cross the mouth of Chesapeake Bay, but Robins, Eastern Bluebirds, swallows, and other diurnal migrants were often seen crossing the bay against southerly winds, and on one unusual occasion (3 November), some 200 Chipping Sparrows and 205 Myrtle Warblers were also seen in this southward movement.

Ocean City, Maryland. During observations in September 1957, Yellow-shafted Flickers, Tree Swallows, Bobolinks, and Baltimore Orioles, together with other diurnal migrants, were seen flying south along the barrier beach, while Tree Swallows tended to fly northward when the wind was blowing from a southerly quadrant (C. S. Robbins, quoted by Baird *et al.*, 1958). In September 1958, however, Yellow-shafted Flickers and warblers were seen flying north as well as south (Robbins, pers. comm.). The numbers involved were small, however, and we hope to investigate the significance of the movements in subsequent seasons.

Hooper Island, Maryland. Mr. C. S. Robbins informs us that this island is well known locally as the site of a pronounced autumn migration of hawks and Yellow-shafted Flickers, which fly northward up the east shore of Chesapeake

Bay. The birds were formerly hunted for food, and Tyrrell (1935) estimated that as many as 1,000 flickers were killed in the course of 29 September 1934. Rusling (1937) recorded flights of up to 700 Yellow-shafted Flickers per day in October 1936, and mentioned two occasions when large numbers of Tree Swallows and Eastern Meadowlarks were also seen flying north.

Cape May, New Jersey. The celebrated diurnal migration at Cape May has been described in great detail by Stone (1937). Diurnal migrants (*e.g.*, hawks, Nighthawks, Chimney Swifts, Eastern Kingbirds, and swallows) frequently pass down the coast in small numbers, and normally most cross the bay southward to the Delaware shore. However, in strong northwest winds, the numbers are vastly augmented, and almost all of the birds turn north on reaching Cape May Point and follow the shore of the bay north for as much as 20 miles. The large numbers appear to be due to the effect of the northwest winds in concentrating the birds against the coast (Allen and Peterson, 1936), while the birds' refusal to cross the bay in offshore winds is a typical example of the effect of wind on the response of migrants to lines of diversion[a] (Deelder, 1949; Tinbergen, 1949; van Dobben, 1953, 1955; Nisbet, 1957b).

Nocturnal migrants regularly take part in the northward movements in the early morning, but (unlike the diurnal migrants) in most cases described, they were seen flying in from the southeast over the sea in large numbers in the early mornings. The principal species involved are American Woodcock, Yellow-shafted Flicker, Robin, and Myrtle Warbler, all of which pass in thousands, but Stone (1937) also mentions that large numbers of Slate-colored Juncos, flycatchers, sparrows, and many other species are also involved at times.

Bridgeton area, New Jersey. Burns (1903) reported that in the region of the Upper Delaware Bay, Yellow-shafted Flickers were found flying north at some time in October of every year, just previous to and during northwest storms. "This peculiarity of flight affects a large territory extending inland from the east shore of the bay some 15 or 20 miles."

Tuckerton, New Jersey. This area of observation is a salt marsh extending for some four miles southeast from the mainland of New Jersey between Great Bay and Egg Harbor. A line of bushes along a road in the center of this marsh acts as an area of concentration for nocturnal migrants. On many visits in 1953 and 1954, Baird noted a general movement of these birds northwestward along these bushes toward the mainland, none leaving westward to make the shorter crossing to the wooded mainland, or southward to cross the narrow stretch of water to the islands of the Brigantine National Wildlife Refuge. A typical observation is that made by Mr. and Mrs. J. V. Moran *(in litt.)* on 27 September 1957, involving over 50 Yellow-shafted Flickers (many of which were seen crossing the open salt marsh), 24 Palm Warblers, 20 Cape May Warblers, and many other nocturnal migrants, all working northwest.

Barnegat Inlet, New Jersey. The south side of this break in the New Jersey barrier beach formerly contained a dune thicket (close to Barnegat Light), which harbored notable concentrations of migrants each autumn. On many occasions in 1953 and 1954, Baird saw small numbers of nocturnal migrants, notably warblers and Baltimore Orioles, depart from this thicket and fly off to the northwest towards the mainland more than five miles away. None was seen to cross the

[a] This term is used in preference to "guiding lines" or "leading lines"; see Lack and Williamson (1959), who define other terms used in this paper.

narrow inlet north to the southern tip of Island Beach, or to follow the beach southward.

Island Beach, New Jersey. During the extensive netting operations on this barrier beach in September 1957, casual observation of visible migration revealed Baltimore Orioles and Cedar Waxwings flying north in the early mornings, while Yellow-shafted Flickers flew south (Mrs. E. Dickerson, quoted by Baird *et al.*, 1958).

Jones Beach, New York. Elliott (1957) mentions frequent occasions when "in the early morning many land birds (up to the size of Flickers) may be seen . . . [over the ocean] flying towards land. This occurs most frequently during times of offshore winds." One such occurrence was seen by Nisbet on 18 October 1958, a steady trickle of Myrtle Warblers flying over the ocean from the southeast and settling in the bushes on the barrier beach. At the same time, larger numbers of Myrtle Warblers and Slate-colored Juncos (several hundred in all) were seen departing from these bushes and flying northwest over the marshes toward the main part of Long Island.

Nichols (1948), describing 50 years of observation in the same general area, referred to a diurnal movement of Yellow-shafted Flickers, Eastern Kingbirds, swallows, Robins, Cedar Waxwings, Bobolinks, and Eastern Meadowlarks westward along the outer beach. He added that at Garden City, 10 miles north of the coast, "one frequently observes . . . on mornings when there has evidently been a heavy night's migration, numbers of Robins or Myrtle Warblers flying north."

Cos Cob, Connecticut. Mrs. M. S. Roesler *(in litt.)* has described northward movements of night migrants seen 10 miles inland from Long Island Sound, along the crest of a ridge running parallel to the Mianus River. These movements are irregular and are not seen every autumn, but recur several times during favorable seasons; they always follow clear, cool nights with light, northwest winds. Most of the birds pass high above the tallest trees, a few stopping for very short periods before continuing north. The principal species involved are warblers and vireos, with smaller numbers of Robins, cuckoos, etc. Some diurnal migrants such as Nighthawks, Blue Jays, swallows, and Eastern Bluebirds are often noted also, their movements sometimes continuing in small numbers into the afternoon, whereas northward movement of night migrants is usually confined to the first four hours of the morning.

More frequently than the northward movement, south- or southwestward movements of nocturnal migrants (involving a similar range of species) are also observed in the same area, but even these occur only a few times each season. In contrast to the northward movements, these southerly movements frequently continue throughout the day, and sometimes occur in the afternoons of the days on which northward movement has been noted in the mornings.

New Haven, Connecticut. During regular observation in the autumns of 1902, 1903, and 1904 on a ridge east of the city, some two miles north of the head of New Haven harbor, Bishop (1905) regularly saw very large numbers of nocturnal migrants flying in directions between northwest and north-northeast during the first few hours of the morning. The species most regularly observed were Yellow-shafted Flicker and warblers (of many species), but Eastern Phoebe, kinglets, Bobolink, Rufous-sided Towhee, Slate-colored Junco, and sparrows were also seen in large numbers at times. Typical diurnal migrants (*e.g.*, hawks, Tree

Swallows, Blue Jays, Eastern Bluebirds, and blackbirds) seen at the same time usually flew west or southwest, but were rarely as numerous as the north-going night migrants. Bishop found that the movement was markedly concentrated at this one point, and suggested that the birds had arrived there by flying north along the eastern shore of the harbor; he was unable to detect any flying west across its mouth. He also described three occasions when large numbers of migrants were seen following the coast at Guilford, 16 miles to the east, but unfortunately does not mention the species.

Trowbridge (1902), describing observations of hawk migration in New Haven and elsewhere on the Connecticut coast, mentioned that "many other species of birds—woodpeckers, thrushes, blackbirds, etc.—make their appearance before sunrise near the Connecticut shore and are abundant for a few hours only, because they soon fly back into the country to feed."

Middletown, Rhode Island. During a special study of diurnal migration in this area in 1958, comparatively little movement of night migrants was observed, but up to 60 Robins and up to 71 Myrtle Warblers were seen on several days, usually following the shore of the Sakonnet River northward, but sometimes crossing in a westerly or northwesterly direction. Both species were seen flying northwest as much as 10 miles inland. Movements of diurnal migrants in this area are much affected by lines of diversion; many species fly between west-southwest and west-northwest when crossing the Sakonnet River and Narragansett Bay, but some—notably the Eastern Kingbird, Bobolink, and Redwinged Blackbird—habitually fly northwest (Baird and Nisbet, 1959).

An additional observation was made on 20 September 1958, when Baird saw large numbers of Savannah Sparrows flying north during the first hour after dawn from the coast in the southeastern corner of Aquidneck Island. No other large diurnal movements of night migrants have been seen in this part of the island, despite four seasons' observation at the Norman Bird Sanctuary, only half a mile inland. These observations suggest that such movements are relatively infrequent in this area, and that those occurring are most noticeable on the coast and the shores of Narragansett Bay.

West Island, Massachusetts. This small island, joined by a causeway to the west shore of Buzzards Bay, was visited by large numbers of warblers and other night migrants on 2, 3, and 5 September 1954, after the passage of a hurricane and a cold front on 31 August. All migrants seen each day flew off northwestward to the mainland in the first few hours each morning, their departure probably being hastened by the lack of food due to the killing of the vegetation by salt spray during the hurricane (Baird, 1955).

Nahant, Massachusetts. On 6 October 1958, Nisbet found a large number of newly arrived migrants, mainly Yellow-shafted Flickers, kinglets, Myrtle and Blackpoll warblers, Slate-colored Juncos and sparrows, in the wooded part of this island. But within two hours after dawn, small parties of juncos and flickers were flying north along the causeway connecting the island to the mainland.

Seguin Island, Maine. Spinney (1898, 1900, 1902, 1903, 1906a, 1906b), the keeper of the lighthouse on this small island, described numerous occasions when large numbers of birds were seen flying in from the east and southeast and continuing west and northwest toward the mainland. The most favorable conditions were "either very dark, moderate nights, or after a strong northwest wind during the night, when at daylight the birds can be seen by hundreds arriving

from seaward." The species most often mentioned were the Horned Lark, Snow Bunting, and (in two seasons) White-winged Crossbill, but sparrows and Slate-colored Junco were regularly present in thousands in late September and October. A still wider variety of birds occurred from time to time at the lantern during the night, often during overcast weather or rain with east or northeast winds.

Brier Island, Nova Scotia. Lewis (1956) described how numerous warblers and other species flew north through this island to the trees near its northernmost point in the early morning of 10 September 1955. On reaching the point, at least one warbler was seen to depart over the sea, but others returned southeastward down the shore of the island.

The Forillon, Gaspé Peninsula, Quebec. Ball (1947), reporting observations made between 1938 and 1946 on this narrow promontory, projecting for five miles southeast from the eastern end of the Gaspé Peninsula, described early-morning movements of large numbers of Red-breasted Nuthatches, which passed northwest out of the promontory, concentrated along the coast and other lines of diversion. The numbers seen varied greatly from year to year, but in good seasons (coinciding with "invasions" in New England), up to 1,188 birds were seen departing in a single morning. Few birds were ever seen entering the Forillon from the west, and Ball concluded that they arrived during the night, and that the fluctuations in the numbers of departing birds observed reflected fluctuations in the nocturnal immigration. The largest numbers occurred in cool, clear weather after the passage of depressions.

In a later paper, Ball (1952) has described in great detail observations of other species migrating in the same area. The observed movements were very confused; the birds showed a great attachment to diversion lines, and many were seen to enter the promontory from the northwest, as well as to depart in the same direction after having flown down to its tip. Ball concluded that many of the birds were engaged in a kind of "trial and error" dispersal along coastal diversion lines, as he later established for the nocturnally migrating thrushes that he specially studied. The behavior of these birds suggests that they were involved in a kind of premigratory dispersal rather than fully motivated migration, as Lowery and Newman (1955) have suggested. However, Ball added (p. 21) that far more birds were seen leaving the Forillon northwestward than were ever seen to enter it, and he concluded that many of the birds arrived at night, although his attempts to detect their arrival were unsuccessful. He gives few details of the species involved, but mentions a wide variety of warblers, thrushes, sparrows, etc., while the few actual counts that he gives suggest that on good days the numbers of birds to be seen migrating ran into hundreds.

Ball attempted to trace the subsequent course of the birds leaving the base of the Forillon, and found that a few turned southeastward to follow the north shore of Gaspé Bay. He gives no adequate counts, but it appears that the numbers of birds following this course were much smaller than those that left the promontory in a northwest direction.

Observations at sea. Although land birds are frequently seen at sea off the Atlantic coast (Scholander, 1955, and many references there and elsewhere), we have only found a few cases where their flight directions there have been recorded. Helmuth (1920), while at sea off the Maine coast, saw many large flocks of Pine Siskins flying north during 2 November 1917. Mr. P. W. Post *(in litt.)* saw one Yellow-bellied Flycatcher, six Tree Swallows, one Cedar Waxwing, and four

warblers during eight hours' observation on 24 August 1958, between 75 miles east-northeast and 40 miles west-southwest of Nantucket lightship; these remained on the ship for periods of up to half an hour, all eventually departing directly northwest. In the same area on 2 October 1956, McDade (1957) saw large numbers of birds (including 100 Yellow-shafted Flickers, 150 Cedar Waxwings, and 300 White-throated Sparrows), mainly flying west or west-southwest. The only record of more than odd birds flying south is that of Gordon (1954), who, in six days at sea, saw a total of 11 birds some 100 miles south of Nantucket and Block Island.

Summary of Observational Data

With the principal exception of those of Nantucket, where daily observation has now been maintained for a number of years, most of the observations described above have been more or less casual. But they are sufficient to show that a north- or northwestward diurnal movement of passerine night migrants is a common feature of fall migration along the Atlantic coast, and on islands and ships offshore. Southwestward movement of some of these species by day has been recorded inland, but so rarely on the coast that it seems probable that the northwestward flight is their normal behavior there, as it is definitely known to be at Nantucket and elsewhere. At some places, the northward movement could be attributed to the effect of lines of diversion on birds unwilling to make a water crossing; but this could not explain the direction of flight at other places, where fall migrants might be expected to fly southwest.

Before attempting to discuss the significance of this northwestward movement, it may be helpful to summarize the observational data and direct attention to its more salient features:

1. Most records have been made on islands and coastal barrier beaches, where the movement is most concentrated and conspicuous. But movement also takes place regularly a few miles inland in Connecticut, and there are several, possibly relevant records 50 to 100 miles inland.

2. At Nantucket all, or nearly all, the common migrants regularly take part in the northwestward flight. But at other places such flight usually involves only a proportion of the species present. Among the commoner species, the most conspicuous participants are usually the Yellow-shafted Flicker, Baltimore Oriole, Slate-colored Junco, and Savannah Sparrow; the least conspicuous are probably the Common Yellowthroat and the White-throated Sparrow.

3. Even though the migration waves on the islands and barrier beaches are often large, it is rare for all of the newly arrived migrants to leave immediately in the northward movement. Repeat records of

banded birds show that the proportion of birds staying for one or more days varies widely from place to place.

4. At some places, where lines of diversion have an important influence on their movements (*e.g.*, Nantucket and Cape May), typical diurnal migrants often take part in the northwestward movements. At other places, however, the directions of flight of diurnal and nocturnal migrants are widely different or even diametrically opposed. A few species (*e.g.*, Yellow-shafted Flicker, Robin, and Bobolink), which may migrate either by day or by night, have been seen taking part in both movements.

5. The observed directions of flight vary at different places between west-northwest and north-northeast, but this variation is probably due largely to local topographic influences. So far there is no evidence for species-specific differences in flight directions.

6. At most places, the birds are strongly influenced by lines of diversion, and at Block Island and Nantucket different species often follow different routes.

7. The movement may be inhibited altogether by unfavorable weather —as at Block Island, where departures were stopped by headwinds greater than 20–25 miles per hour.

8. In most places, migration takes place only during morning hours, with different species often migrating at different times. However, at Nantucket, where the most detailed observations have been made, the peak times of migration vary somewhat from day to day, and there is often heavy migration in the afternoon. It remains to be determined whether such variations are due to differences in the times of arrival of the birds, or to variations in the weather as it affects departures.

9. Sea-crossings may be undertaken by birds without fat reserves.

10. There is one observation of northward migration at night following a large wave of arrivals on the previous day.

Discussion

Theories of Coastal Migration

Many writers, noting the correlation between large arrivals of nocturnal migrants on the coast and northwest winds, have surmised that the birds have been concentrated there by offshore winds, and some (Trowbridge, 1902; Allen and Peterson, 1936; Stone, 1937; Garrison, 1937; Griscom and Folger, 1948; Griscom, 1949) have suggested that the birds have been drifted eastward to the coast from an inland migration route. In the case of Nantucket, Dennis and Whittles (1955) point out that such drift during nocturnal flight could account for the

arrival of some of the migrants, but they suggest that the majority are in fact diurnal migrants, and arrive at Great Point from the north after a daylight crossing from Cape Cod. From analogies with migration as observed in Europe, they argue that the migration on Nantucket is the "final stage in a pronounced coasting movement which very well may have its origin several hundreds of miles to the north," and that the birds, normally nocturnal migrants, are forced to continue their flight during the day when over the inhospitable coastal habitats. Although such diurnal migration has not been recorded on Cape Cod, they point out that it could well occur unseen, and that the concentrations of birds observed there in northwest winds could arise from the precipitation of such diurnal migrants in danger of being blown out to sea. At Cape Cod, they argue, the effect of diversion lines would be to channel the birds into a narrow front, inducing them to cross to Nantucket, where the coast and other lines of diversion would lead them around to the western point and off to the northwest. The abundance of southern and western rarities in such a movement is explained by their staying "with the movement until the end, presumably because they are lost and are merely tagging along with the others."

Impressed by the arrival of different species at different times during a three-day period of maximum migration, they suggest that "an appreciable proportion of our birds reach us from Nova Scotia and other northerly points by an over-water route." Still more recently, Dennis (1957–1958) has mapped this hypothetical route from Nova Scotia and Maine to Cap Cod and Nantucket, and suggested that some of the birds arriving in this general area during the day had actually started the sea crossing at night.

While some of the arguments in these papers will need to be discussed later, it is sufficient at present to point out that none of them could explain the northward flight at Block Island or any of the places mentioned above. Other theories invoked to explain the reversed migration at specific places—*e.g.*, the following of lines of diversion (Bishop, 1905; Stone, 1937; Ball, 1947); following of tributary streams to reach a migration route in a large river valley (Allen, 1903); trial and error dispersal (Ball, 1952); downwind orientation (Devlin and Wykoff, 1958); dispersal to feed (Trowbridge, 1902); return to land after offshore drift (Spinney, 1898; Stone, 1937)—similarly cannot be extended to all the places where this northward flight has been observed. The northward movements usually coincide with north or northwest winds, so that in places where the birds are following well-marked topographical features (*e.g.*, Cape May, Hooper Island, or Nantucket), most of them could be dismissed as retromigration—the

well-known tendency for low-flying birds to follow lines of diversion into the wind (Vleugel, 1955; Lack and Williamson, 1959). There is much evidence, however, that this is not a complete explanation of the observed phenomena. In some places, the movements take place in areas without well-marked topographical features (*e.g.*, at Bridgton or at sea), or the birds cross prominent lines of diversion without change of direction (*e.g.*, at Jones Beach and New Haven). Moreover, in the places where the relation of the movements to weather has been reported in the greatest detail (New Haven and the Forillon), there is a poor correlation between the directions of the birds and the wind, while at Nantucket northwest movement regularly occurs in calm weather (Dennis, *in litt.*). Finally, coasting movements in the expected direction (south or southwest) are rarely observed, even in south or southwest winds, at least at low altitudes. We conclude that, while weather and topographical influences may at times help to concentrate the birds into spectacular numbers, they cannot account for all of the observed features of the northwest movements. In the remainder of this paper we will attempt to put forward an explanation of the widespread occurrence of this northward flight.

Importance of Wind Drift

Dennis *(in litt.)* informs us that observations on Nantucket subsequent to 1955 have suggested that Dennis and Whittles (1955) then underestimated the importance of wind drift. However, these authors present several important objections that must be considered before the drift theory can be applied to any major portion of the migrants there:

1. The birds arrive too regularly and in too large numbers for their occurrence to be regarded as accidental.

2. The birds are diurnal migrants, whereas drift should act primarily on nocturnal migrants.

3. The birds do not arrive only when the wind is offshore.

Let us consider these arguments in order:

1. The concentrating effect of islands is well known (Svärdson, 1953; Otterlind, 1955; Cornwallis, 1955). By such standards, the numbers of birds that reach Nantucket do not seem to be phenomenally large (see tables in Dennis and Whittles, 1955, 1956; cf. Gätke, 1891; Clarke, 1912; Baxter and Rintoul, 1918; Lowery, 1945; Bergman, 1951; Edelstam, 1951). The regular occurrence of drift migrants at Nantucket could be explained by the fact that the prevailing wind is offshore; it is well known that migration phenomena on the mainland

are associated with northwest winds (Trowbridge, 1902; Stone, 1937; Baird *et al.*, 1958, 1959). Moreover, as explained below, Nantucket is well placed to receive drift migrants from widely separate sources.

2. The daytime movements on the islands form the main topic of this paper and will be discussed later. The chief evidence for the contention that the birds arrive at Nantucket by day is the fairly frequent observation of arrivals at Great Point (Dennis, *in litt.*). But in the only such case that is described by Dennis and Whittles, the exhausted condition of the birds could hardly have been the result of the 10-mile crossing from Monomoy. Indirect evidence, such as the rarity with which nocturnal migrants were heard over Nantucket, and negative results from "moon-watching" there and on Cape Cod (Dennis and Whittles, 1955), have been contradicted in part by later, aural observations (Dennis, *in litt.*), while radar observations have recently shown that large-scale, nocturnal migration occurs regularly in this area (Richardson *et al.*, 1957, 1959). Migrants undoubtedly reach the other islands at night—at Block Island on 13 October 1958, for example, large numbers of birds were present before dawn. Finally, diurnal migration as seen on the adjacent mainland (Baird and Nisbet, 1959) involves just those species that are poorly represented on the islands, and the few nocturnal migrants seen moving on the mainland by day were in fact the species that showed the greatest reluctance to cross water.

3. Dennis and Whittles (1956), in describing an unusually large wave of arrivals at Nantucket on 12 October 1955, in west to southwest winds, asserted that this constituted "a final refutation of the concept that migration in the southeastern coastal regions is a product of northwesterly winds." However, it is well known that migration on Nantucket and the New England coast is usually associated with northwest winds (Dennis and Whittles, *op. cit.*; Baird *et al.*, 1958, 1959), and such anomalous cases therefore deserve special attention. The weather map for the previous night (Figure 4) shows a "low" receding northeastward over Newfoundland, and a flow of Polar air from the northwest over the Gulf of St. Lawrence and Nova Scotia, as a high-pressure ridge extended into Maine; the associated cold front moved slowly southward across the Gulf of Maine to reach Nantucket on the afternoon of the 12th. With clear skies and a sharp temperature drop in northern Maine and Nova Scotia, numbers of birds must have departed during the night, and doubtless many were drifted out to sea by the offshore winds. In the generally northerly winds prevailing over the Gulf of Maine, the most likely landfall for these birds, after flying through the front, would be Cape Cod and Nantucket. The continuance of migration through Nantucket until midafternoon on the 12th is incompatible with the hypothesis of a "deliberate" crossing from Nova Scotia, but can easily be explained in terms of offshore drift. Of course, other birds may have reached Nantucket at the same time by crossing directly from northern New England, but clearly the weather situation alone cannot be used as evidence for such a movement.

This case has been discussed in detail because the weather situation involved is typical of those that prevail when birds arrive at Nantucket in northeast, north, or southwest winds. Migration in northeast winds is usually associated with high-pressure centers or ridges in eastern Canada, which bring offshore winds to Maine, Nova Scotia, and Newfoundland. At least some of the birds arriving at Nantucket in these conditions must thus be the victims of drift from these more-northern areas. In some of these weather situations, where the wind is from the north over the Gulf of Maine, nocturnal migrants may reach Nantucket along

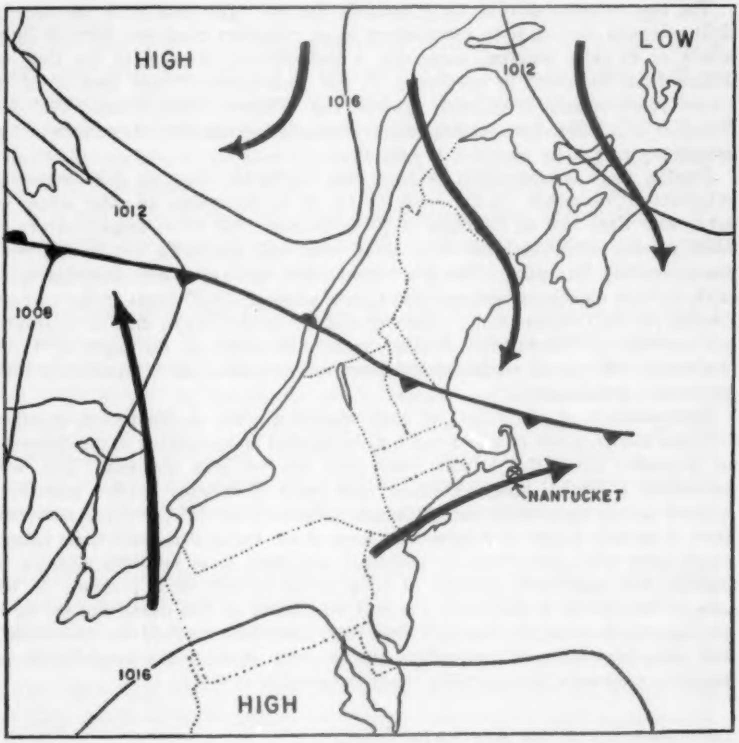

Figure 4. Simplified weather map for 0130 E.S.T. on 12 October 1955 (derived from the Daily Weather Map of the U.S. Weather Bureau). The heavy arrows denote the general direction of the airflow near the surface.

the exact routes postulated by Dennis (1957–1958), yet still be the victims of drift! Southwest winds at Nantucket are usually the return flow of tropical air on the west side of a high-pressure cell centered off the mid-Atlantic coast, and there is much circumstantial evidence that the birds reaching Nantucket under these conditions arrive, not from the north but from the *southwest* (Baird *et al.*, 1959). In cases such as that illustrated in Figure 4, when a front extends from east to west close to Nantucket, drift migrants from the northeast may fly through the front and arrive in southwest winds, while in analogous cases, migrants from the southwest may arrive in east or northeast winds. Indeed, in many of these cases, it is possible that birds may reach Nantucket from both sources simultaneously. It is a well-known feature of places where drift migration is important that birds may arrive from different sources in different weather conditions (Williamson, 1955; Cornwallis, 1955, 1956), and the position of Nantucket is indeed uniquely favorable to receive drift migrants from several different directions.

The best evidence against the hypothesis that the Nantucket birds are largely drift migrants derives from cases where large migration continued there in light winds or in calm weather, suggesting a well-oriented crossing of the Gulf of Maine from the north or northeast. A few such instances have been noted in recent years, mainly in October (Dennis and Whittles, 1956; Dennis, 1957-58; Baird *et al.*, 1959), but, pending more thorough investigation, they seem to be sufficiently rare to be regarded as exceptions.

Finally, there is now direct evidence that northwest winds do drift nocturnal migrants to Nantucket. A film made by Dr. R. E. Richardson of radar echoes of birds over Cape Cod on the night of 10-11 October 1957 shows large numbers of birds passing south-southeast on a broad front and continuing out to sea, with many reaching Nantucket. The weather was then cool (after cold-front passage), with variable cloudiness and north-northwest winds of 15-20 knots at the surface. Dennis (*in litt.*) reports that 11 October was one of the largest days of migration yet recorded at Nantucket. Another radar film made on the night of 19-20 September 1957 shows northeastward movement in tropical air of exactly the kind previously mentioned.

Determination of the origin of each migration wave at Nantucket or other offshore islands would require a much more detailed understanding of the dynamics of migration along the Atlantic coast than has yet been obtained. This will necessitate a detailed study extending over years of varying weather patterns—a study as yet only in its earliest stages (Baird *et al.*, 1958, 1959). However, there is already reason to suppose that most of the waves that reach these islands result from wind drift from the mainland, and there is as yet little evidence to indicate that significant numbers of birds arrive by any other process. In the case of Nantucket, in particular, the only alternative to thus classifying the birds as vagrants is to accept the fact that they could have evolved an unnecessary and hazardous nocturnal migration over a long stretch of water—despite an apparent preference for migrating when the wind is offshore!

Interpretation of the Northwest Flight

Perhaps the best argument for the importance of wind drift derives from the northwest flight described in this paper. The occurrence of this reversed migration in widely different geographical situations is easily understood when it is realized that most of the birds involved have been drifted southeast of their preferred routes: they are merely setting out to return to them. Such "redetermined passages" following migrational drift is now well established in Europe (Williamson, 1953; Jenkins, 1953; Cornwallis, 1955; Nisbet, 1957a, 1957b; Lack, 1959), and has even been demonstrated experimentally (Sauer, 1957). The same explanation can be advanced for the northwest movement of birds seen over the Atlantic far out of sight of land; for these birds, a northwestward flight is usually the quickest way to regain the mainland.

We now begin to see how the system may actually operate. Each cold-air mass that erupts southeastward over the Northeast tends to drift nocturnal migrants towards the coast. Some birds eventually drift

out to sea, even on clear nights when it might be expected that they could see the coast. At some stage—perhaps at first light—the birds detect their drift and attempt to correct for it. Those over the coast or near islands are able to stop, resulting in the transient concentrations that are observed there, but those over the sea must turn and fly back toward the mainland, presumably orienting by means of the sun (Kramer, 1952; Matthews, 1955) or the wind (Stone, 1937; Vleugel, 1954, 1955) if out of sight of land. These returning birds arrive during the course of the day, accounting both for fluctuations in numbers on islands and for occurrences on ships near land in late mornings or afternoons.

Meanwhile, those birds that have stopped on the islands also detect their drift—either by some process of navigation or merely from the proximity of the sea—and respond by setting out to fly north or northwest. "Diverted" by the shores of the islands and influenced by factors such as the strength of the wind, they become concentrated at the northernmost prominences and take off toward the mainland. Their behavior on arrival at the coast is not yet known, but it seems probable from the scattered observations there that at least some continue to fly inland.

In addition to these birds seen flying in from the sea, birds are already present in large numbers on the mainland coast before dawn, and it is evident that they have been concentrated there during the night. The mainland observations, *e.g.*, those made by Trowbridge (1902) at New Haven, show that many of these birds also depart northward, suggesting that they too have been drifted coastward from inland migration routes.

Within this generalized picture, there are many effects of local topography that remain to be worked out in detail. Although the observational data are still scanty, it is already clear that there are wide local variations in the frequency of this reversed migration and of the behavior of the birds, which can be resolved only by intensive local study. Moreover, the observed pattern is greatly complicated by interspecific differences in migration routes and in response to weather and topography. However, the north or northwest flight is common to so many different species, and occurs at so many different places, that it seems reasonable at present to regard it as a simple—perhaps automatic—reaction to lateral displacement; its function being correction of this displacement, regaining of the mainland (for those birds that have been drifted out to sea) and a return to the main migration route. Of course, this interpretation need not exclude the application of other theories to some species and some localities, but it seems to be the only one capable of explaining all the observed aspects of the phenomenon.

Three main problems are immediately raised by this interpretation, however:

A. It seems surprising at first sight that the birds should fly north or northwest, although a westward flight would have the advantage of returning them to a point farther south on their migration route. It seems likely that this preferred direction is in itself an adaptation to avoid drift, since a bird at sea heading west or southwest in a strong, northwest wind would continue to drift farther offshore. The northwestward flight is in fact the simplest reaction that would counter such drift and return the bird, whether over land or over water, to its preferred migration route, and it reveals the necessity for effecting this return as quickly as possible. Thus, the birds cannot be "voluntarily" drifting offshore, as part of a system of "pressure pattern flying" (McMillan, 1938; Landsberg, 1948; Lowery, 1951; Williamson, 1955), for any advantage they might have gained by deliberately drifting southward with the wind is immediately cancelled when they set out to return upwind.

B. It is still unknown what fraction of the wind-drifted birds fail to reorient their flight, but continue to drift out to sea. Records of birds on ships far out in the Atlantic (Scholander, 1955), at Bermuda (Bradlee *et al.*, 1930; D. B. Wingate *in litt.*), and even in Europe (Alexander and Fitter, 1955) suggest that many must be lost in this way, but the northwestward orientation of the birds seen near the coast is so strong that it is hard to understand why the others do not also attempt to return. It is hoped that Wingate's current migration studies on Bermuda will shed some light on this problem.

C. It is difficult to explain why birds that have reached safe resting and feeding areas on the islands should leave them and return immediately to the mainland, rather than wait until their normal migration period the next evening (as drift migrants appear to do in Europe). Many of the birds have little fat remaining, yet they set out on a new sea crossing, often against a headwind so strong as to give them little chance of survival if it should increase even slightly. Since offshore winds may persist for 48 hours or more after cold-frontal passage, it is conceivable that it might be safer for some species to cross to the mainland in daylight, when they can orient visually, than at night when they may be unable to detect additional drift. Another possible advantage gained by leaving immediately might be that the limited food supply available on the islands and barrier beaches is inadequate for the large numbers of birds that sometimes occur there. Neither of these explanations is perhaps fully convincing, but the net advantage gained by this behavior may in any case be rather small, since some species do not share it.

In conclusion, it is interesting to note that some truly diurnal migrants that pass through southeastern New England have developed a similar adaptation to counter the danger of drift offshore. The main migration routes of most diurnal migrants in this area lie some distance inland, but some of these birds (the numbers varying from year to year) wander south to the coast, either by wind drift or through following lines of diversion. Many of these birds set out northwestward across the mouths of the bays, even though westward flight would be more in accordance with their standard direction and would in some cases result

in a shorter water crossing. Analysis of their behavior suggests that these birds are reacting primarily to the proximity of the sea (Baird and Nisbet, 1959).

The Importance of Drift in the Migration through the Northeast

The above arguments provide a plausible explanation of the observed movements, but they invite an important objection. If offshore drift is so important that the birds migrating through this area have evolved a special reaction to counter it, why have they not developed more efficient adaptations to the same end? Specifically, why do they not avoid the coast altogether and develop migration routes far inland? Why should they start their migration in northwest winds, and not develop a reaction to migrate in the calmer weather of the second or third nights following cold-frontal passage, as is found in Europe among hawks (Rudebeck, 1950) and some passerine night migrants (Nisbet, 1957b)?

There is, in fact, evidence that many of the birds that pass through the Northeast have developed such adaptations. For the reasons discussed elsewhere in this paper, the occurrence of large concentrations of birds along the coast is not evidence that significant numbers follow a coastal route (cf. Lowery, 1946). We have already shown that large numbers of migrants are drifted to the coast of the mainland, and the question naturally arises whether any significant numbers of birds arrive there by any other means. Observed migration on the coast, like that on the offshore islands, is in fact highly correlated with offshore winds (Baird *et al.*, 1958, 1959)—a conclusion that applies not only to areas such as southeastern New England (Garrison, 1937) and Cape May (Allen and Peterson, 1936), which are well to the southeast of the main trend of the Atlantic coast, but also to the coast of Maine and the New York City region, which must be part of any supposed system of coastal and river valley migration routes (Griscom, 1923, 1933, 1940, 1941, 1949; Bagg, 1923; Allen and Peterson, 1936; Lincoln, 1939, 1950; Nichols, 1948; Squires, 1952; Dennis, 1957–1958). A suggestive piece of evidence that concentrations of passerine night migrants on the coast are in fact dependent on drift due to offshore winds was obtained in September and October 1958, when a banding station 25 miles inland at Jamesburg, New Jersey, consistently reported peaks of migration in calm, high-pressure weather, one day later than the corresponding peaks (in northwest wind) at Island Beach, New Jersey, or coastal Long Island (Baird *et al.*, 1959, where other circumstantial evidence is quoted). If birds do follow the coast in any num-

bers, it is hard to explain why southward diurnal movements of night migrants are so rare there, although they are frequent enough 100 miles or more inland (Broun, 1945; Brooks, 1958; Eliot, 1935). The southwestward movements of nocturnal migrants occasionally seen in southern Connecticut, 40 miles from the Atlantic coast, may perhaps indicate a slight shifting of the southeastern fringe of the main body of transients, caused by northwest winds.

Conclusive proof of the existence of coastwise migration would admittedly be difficult to obtain, but almost all evidence available at present supports the hypothesis that most species of passerine night migrants reach the coast in numbers only as a result of wind drift (or other kinds of vagrancy) from their preferred migration routes inland. As exceptions, we might expect that populations that both breed and winter close to the coast might follow a genuinely coastal route; but if so they seem to be greatly outnumbered by drift migrants at the coastal observation stations.

Several anomalous features of the fall migration on the coast—*e.g.*, the high incidence of vagrant species (Dennis, 1957–1958); the high proportion of immature birds (Robbins, Bridge and Feller, 1959; Baird, unpublished); the absence of any regular concentration of diurnal migrants, at least in New England (Baird and Nisbet, 1959)—would find a ready explanation in this hypothesis. All these are characteristic features of migration at places where drift is important (Williamson, 1952; Jenkins, 1953; Svärdson, 1953). It is widely accepted that most long-distance migrants avoid the coast in spring (Griscom, 1933, 1941); the apparent difference in fall could be due largely to the presence of immature birds, which are well known to be less-successful navigators than adults (Drost, 1938; Rüppell and Schüz, 1948; Schüz, 1951; Perdeck, 1958) and to be more liable to be drifted off their course (Dwight, 1903).

In the same way, the occurrence of drift migrants along the coast is likely to exaggerate the extent to which birds migrate there after cold-front passage. Since drift is an important factor influencing their migration, those coastal breeding populations that have genuinely coastal migration routes should have developed some kind of adaptation to avoid migrating in northwest winds. The best-known example of this is the Catbird, which seldom figures prominently in the coastal waves that occur in northwest winds, but seems to migrate in largest numbers in the calmer weather two or three nights after a cold-front passage (Baird *et al.*, 1958, 1959). This species is thus well adapted to a coastal migration route, while the relative abundance of other species at coastal points may merely reflect the dangers of drift.

However, neither of these adaptations could preclude the danger of drift over the sea. The initiation of migration in passerines probably depends on a complex balance between the internal drive and external factors that act as inhibitors and releasers (Nisbet, 1957b). Thus, there are always weather situations that will defeat an adaptation to avoid migrating in northwest winds—*e.g.*, a long period of storms followed by a strong cold front, or an unusually prolonged period of northwest wind (such as that which led to the large wave on Block Island on 13 October 1958, described earlier in this paper). Even the special adaptation exhibited by the Catbird (see above) is not without its dangers, for migration peaks of Catbirds on outlying parts of the coast appear at times to be due to coastward drifting[3] in southwest winds (Baird *et al.*, 1959). Nor would adaptation to a migration route even 100 miles inland preclude drift to or beyond the coast for certain inexperienced or unlucky individuals.

The migratory behavior of many bird populations of northeastern North America may thus reflect a balance between the advantages gained by migrating close to the coast and by migrating in Polar air, and the danger thereby incurred of being blown offshore. For birds that "deliberately" migrate along the coast, the danger of drift is so serious that they seem to have evolved a special reaction to avoid migrating in offshore winds; those that migrate far inland, however, are able to exploit the advantage of migrating in northerly winds with little risk of drift to the coast. According to this hypothesis, the presence of birds on the coast would reflect not the well-adapted migratory behavior of these populations, but rather the active selection that is operating to maintain the adaptations. At any rate, it is clear that a reaction such as the redetermined migration to the northwest that is described in this paper will always be advantageous, however else the birds may be adapted to avoid drift.

Further progress in understanding the dynamics of the coastal migration will depend on more sophisticated methods of observation and analysis. Future research will be concerned with elucidation of interspecific differences in weather-migration pattern and behavior, attempts to determine more precisely the numbers involved in the migratory flights and their directions of movement, and more detailed examination of trapped migrants. We have attempted to demonstrate in this paper, however, that drift over the sea is common in migration in the coastal regions, and that detailed observation of birds subjected to it, whether

[3] In view of the earlier remarks on the preponderance of immature birds among drift migrants it is interesting to note that 95 per cent of the Catbirds trapped in the fall at Middletown, Rhode Island, are immature (Baird, unpublished).

at sea, on islands, or on the coast, is essential for solution of the problems involved.

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SUMMARY

Recent observations of fall migration at Nantucket Island, Massachusetts, and Block Island, Rhode Island, have shown that many nocturnal migrants pass rapidly through the islands and leave in a north or northwest direction during daylight hours.

Similar diurnal movements of night migrants to the north or northwest have frequently been observed at other places along the Atlantic coast from Virginia to the Gulf of St. Lawrence: they have also been noted at sea and at several places inland. Southwestward movements of these species by day have been noted inland, but are very rare on the coast. Published and unpublished observations of these movements are reviewed in detail.

We think that most of the birds that reach the outlying islands do so as a result of wind drift from migration routes over the mainland; there is as yet no convincing evidence for recent suggestions that the islands form part of the normal migration routes of these birds. The largest numbers of birds arrive after being drifted toward the coast by northwest winds, but northeastward movements also occur in southwest winds.

The northwestward flight is interpreted as "redetermined passage," *i.e.*, attempts by wind-drifted birds to regain their preferred migration routes. Some birds reorient northwestward while at sea out of sight

of land, while others start their northward flight from points on the mainland.

Drift over the sea appears to have been an important factor influencing migration close to the coast, and many of the nocturnal migrants that pass through the Northeast appear to have developed other ways of avoiding it. In particular, many species seem to have developed migration routes a little distance inland, and their occurrence on the coast is mainly a result of drift.

Some diurnal migrants appear to have similar adaptations.

APPENDIX

Scientific names of species mentioned in text

hawks (Falconiformes)
American Woodcock *(Philohela minor)*
cuckoos (*Coccyzus* spp.)
Common Nighthawk *(Chordeiles minor)*
Chimney Swift *(Chaetura pelagica)*
woodpeckers (Picidae)
Yellow-shafted Flicker *(Colaptes auratus)*
flycatchers (Tyrannidae)
Eastern Kingbird *(Tyrannus tyrannus)*
Eastern Phoebe *(Sayornis phoebe)*
Yellow-bellied Flycatcher *(Empidonax flaviventris)*
Horned Lark *(Eremophila alpestris)*
swallows (Hirundinidae)
Tree Swallow *(Iridoprocne bicolor)*
Barn Swallow *(Hirundo rustica)*
Blue Jay *(Cyanocitta cristata)*
Red-breasted Nuthatch *(Sitta canadensis)*
Brown Creeper *(Certhia familiaris)*
House Wren *(Troglodytes aëdon)*
Long-billed Marsh Wren *(Telmatodytes palustris)*
Catbird *(Dumetella carolinensis)*
Brown Thrasher *(Toxostoma rufum)*
thrushes (Turdidae)
Robin *(Turdus migratorius)*
Hermit Thrush *(Hylocichla guttata)*
Eastern Bluebird *(Sialia sialis)*
kinglets (*Regulus* spp.)
Water Pipit *(Anthus spinoletta)*
Cedar Waxwing *(Bombycilla cedrorum)*
vireos (*Vireo* spp.)
warblers (Parulidae)
Cape May Warbler *(Dendroica tigrina)*
Myrtle Warbler *(Dendroica coronata)*
Bay-breasted Warbler *(Dendroica castanea)*
Blackpoll Warbler *(Dendroica striata)*
Palm Warbler *(Dendroica palmarum)*
Common Yellowthroat *(Geothlypis trichas)*
blackbirds (Icteridae)
Bobolink *(Dolichonyx oryzivorus)*
Eastern Meadowlark *(Sturnella magna)*
Redwinged Blackbird *(Agelaius phoeniceus)*
Baltimore Oriole *(Icterus galbula)*
Rusty Blackbird *(Euphagus carolinus)*
Pine Siskin *(Spinus pinus)*
White-winged Crossbill *(Loxia leucoptera)*
Rufous-sided Towhee *(Pipilo erythrophthalmus)*
sparrows (Fringillidae)
Savannah Sparrow *(Passerculus sandwichensis)*
Slate-colored Junco *(Junco hyemalis)*
Chipping Sparrow *(Spizella passerina)*
Field Sparrow *(Spizella pusilla)*
White-crowned Sparrow *(Zonotrichia leucophrys)*
White-throated Sparrow *(Zonotrichia albicollis)*
Snow Bunting *(Plectrophenax nivalis)*

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A STUDY OF THE FORAGING BEHAVIOR OF TWO SPECIES OF ANT-TANAGERS

EDWIN WILLIS

THE great similarity in appearance of the Red-crowned Ant-Tanager *(Habia rubica)* and the Red-throated Ant-Tanager *(Habia gutturalis)*, widely sympatric denizens of the undergrowth of Central American lowland forests (Figure 1), raises a number of questions. Some of the most interesting relate to the ecological niches of the ant-tanagers, and in particular to their reputedly similar foraging activities. In an attempt to discover differences and similarities between these sibling species, I conducted field studies in British Honduras from February to early August 1957.

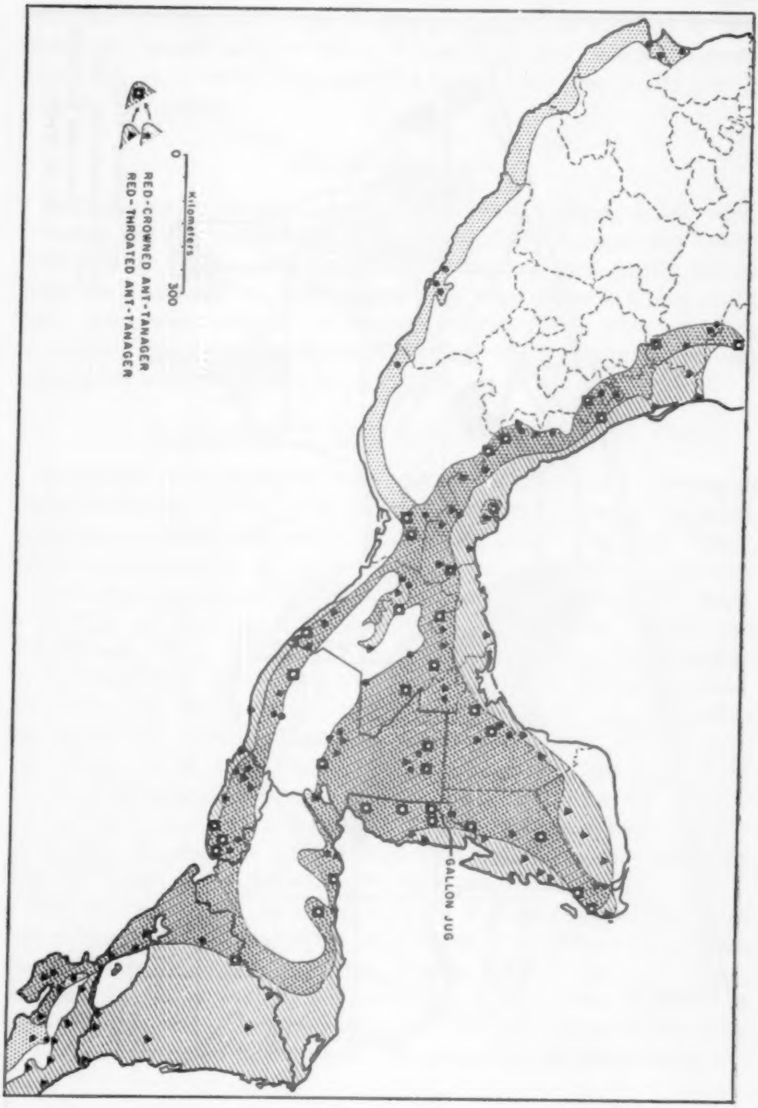
Hellmayr (1936: 300–316) recognizes three species of *Habia*. In *H. rubica*, with subspecies ranging from Mexico to southern Brazil, males are dull red, with a short crest bordered by narrow, blackish stripes; females are mainly olive, with a yellowish crown patch. The complex of forms included in *H. gutturalis*, ranging from Mexico to the valleys of central Colombia, is more varied. The forms (*salvini* group) north of Costa Rica resemble *H. rubica*, but males have duskier cheeks and lack the dark borders of the crests. Females lack the yellowish crown, are browner on the breast, and have a more distinctly yellow throat. The third species, *H. cristata*, is restricted to the mountains of western Colombia; both sexes are red and have long crests. The British Honduran populations are designated by Hellmayr as *H. rubica rubicoides* and *H. gutturalis rooensis*. In general appearance, these ant-tanagers are rather similar to the Hepatic Tanager *(Piranga flava)*, but they differ in habitat and behavior.

Other bird names used in this paper come from Blake (1953).

THE STUDY AREA

In early March, I set up a study area of 42.6 hectares (approximately 105 acres) of "evergreen seasonal forest" (Beard, 1955) on the rolling hills about a kilometer north of Gallon Jug, British Honduras (17°33' N, 89°02' W), at about 125 meters above sea level. A grid of compass-line paced trails (the broken lines in Figure 2), established with the help of a local boy and his machete, proved valuable in many phases of

Figure 1 (p. 151). Probable distribution of Red-crowned Ant-Tanagers, *Habia rubica* (stippled), and Red-throated Ant-Tanagers, *Habia gutturalis* (diagonal), from Costa Rica north. This shows all areas where the two species are known to be sympatric except a small area in Panama.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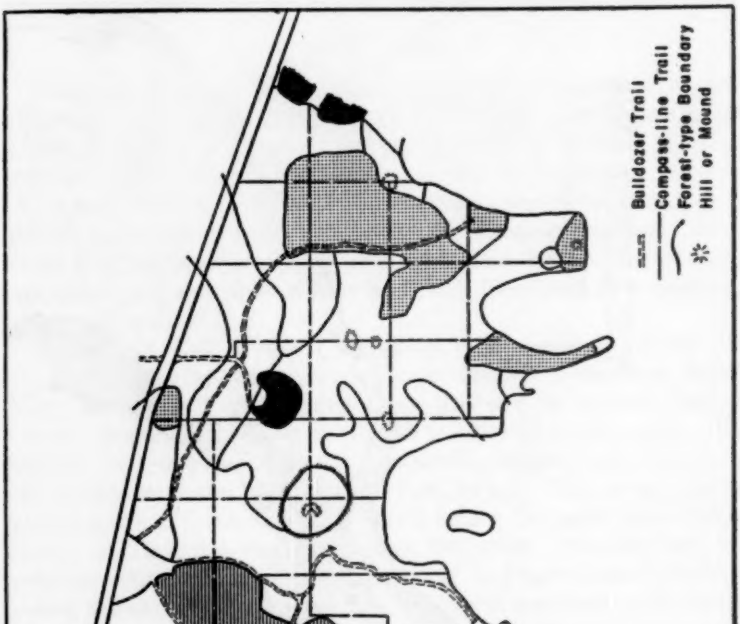
RED-CROWNED ANT-TANAGER
RED-THROATED ANT-TANAGER
GALLON JUG


N
Bulldozer Trail
Compass-line Trail
Forest-type Boundary
Hill or Mound

the study. The vegetation types marked on Figure 2 are discussed elsewhere (Willis, 1958); for present purposes, it is sufficient to note that "high huamil" refers to Moho *(Belotia campbellii)* and other second growth six to 15 meters high and "low huamil" to dense second growth of under six meters.

General Behavior

Both species of ant-tanagers are highly vocal, scolding loudly when a human intruder enters their haunts, but quickly disappearing behind the vegetation when a close approach is attempted. Red-throats seemed particularly inquisitive; their rasping calls were common noises of the dark, lower layers of forest and second growth. Red-crowns were less inquisitive, but easier to follow and observe; their voluble chatter was often given when they were in plain sight.

Differences in Distribution and Habitat

A number of ornithologists have reported Red-crowns commoner at higher elevations, even into subtropical cloud forests (in El Salvador, according to Dickey and van Rossem, 1938; and in San Luis Potosí, México, according to R. J. Newman, personal communication), and Red-throats commoner at low elevations, especially on the coastal plains.

Several ornithologists (Paynter, 1955; Peters, 1929; Dickey and van Rossem, 1938; Sutton, 1951a; and others) have noted differences in the forest-type preferences of the two species in Central America. At Gallon Jug, there were also slight differences in this respect between the ant-tanager species. There the Red-crowns rarely foraged outside the borders of the high forest, and generally avoided the edge of the forest. High huamil was used, especially when the sun was low (Figure 3), but low huamil was rarely visited. Red-throats showed less aversion to huamil, foraging not only through high huamil but also along the edges of woods or low huamil bordering roads or plantations.

One Red-throat pair drifted through the first-year huamil out to the forest "island" to the west of the center study area (Figure 2) at times, but the local Red-crown pair never left the shade of the main forest, although the island was suitable Red-crown habitat. Just southwest of the study area was a small, isolated patch of forest in which lived a group of Red-throats but no Red-crowns. The group used the surrounding low

Figure 2 (p. 152). The study area and its vegetation. Second-growth successions are shaded (fields, solid; low huamil, lined; high huamil, stippled). Forest is unshaded. Length of N arrow represents 100 meters.

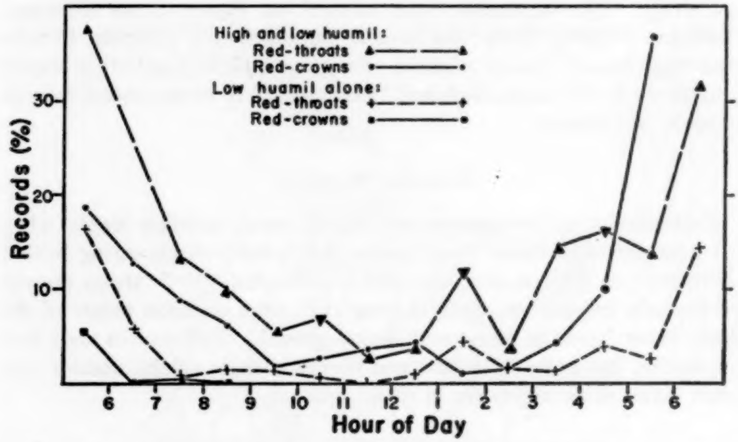


Figure 3. Occurrence of ant-tanagers in second-growth or "huamil" at different hours of the day. Computed as percentages of 3,485 recorded observations for the Red-throated Ant-Tanager and 2,726 for the Red-crowned Ant-Tanager.

huamil for part of its territory, as did many of the forest-edge Red-throat pairs on my study area. I have seen Red-throats, while foraging along the edge of a cornfield, dash out into it after insects. Once I saw a male alight on a gravel road and hop along, jay-fashion, with head high and tail slightly raised.

Wherever the high forest around Gallon Jug had been reduced to a mosaic of plantations, huamil, and forest, Red-throats were generally more common than Red-crowns. But in unbroken areas of hill forest Red-crowns outnumbered Red-throats. The forest of the study area was intermediate between these extremes, and the two species were approximately equal in abundance.

Differences in Foraging Level

To gain an idea of the vertical distribution of the two ant-tanager species in the forest of the study area, I made estimates of the height at which the birds perched while foraging and recorded each such estimate in one of 12 divisions: 10 strata, each a meter deep, plus a separate category for the ground and another for above 10 meters.

Although the resulting 4,000 estimates for Red-throats and 5,000 for Red-crowns (presented in percentages in Figure 4) should be interpreted with caution, a few generalizations are probably safe. Most

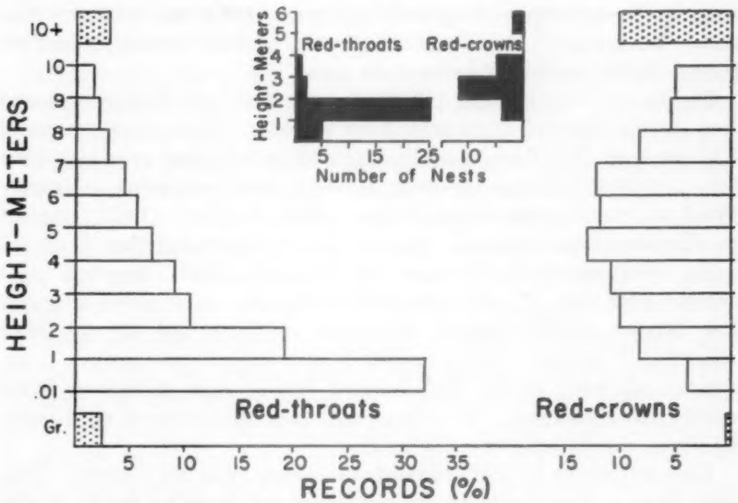


Figure 4. Height (in meters) of ant-tanager foraging and of nests (inset). Percentages are based on 4,000 records of foraging height for Red-throated Ant-Tanagers and 5,000 records for Red-crowned Ant-Tanagers.

important, Red-crowns generally foraged higher than Red-throats. Moreover, it seems that the Red-throats are restricted to a narrower as well as a lower foraging stratum. In foraging near the ground, the Red-throats have departed farther than the Red-crowns from "typical" tanager foraging style: according to Skutch (1954), most tanagers are tree-top or upper-level birds. There may be some correlation between ordinary foraging height and nest height (Figure 4).

Red-crowns sometimes, particularly in the early morning and late afternoon, foraged high in the under-canopy of the forest, 20 and more meters above the ground. Red-throats never approached such a height while foraging. On the other hand, Red-crowns rarely visited the ground except when looking for an insect that had dropped before capture. But the ground was an important source of food for the Red-throats, which regularly followed the army ants.

Ant-Tanagers and Army Ants

In the American tropics, swarming army ants *(Eciton burchelli* and *Labidus praedator)* in search of prey stir up many fleeing insects and other arthropods from the forest floor (see Schneirla, 1947). Where such ants occur, certain birds habitually attend the ant swarms and

snap up the arthropods they flush (Johnson, 1954, and others). The name "ant-tanager" was doubtless adopted because naturalists had reported *Habia* species following these ants.

Dickey and van Rossem (1938) thought that both Red-crowns and Red-throats followed army ants in El Salvador. Two other reports of Red-crowned Ant-Tanagers following swarms of army ants may have been misidentifications: Nutting (1883) took specimens, originally listed as *Phoenicothraupis rubicoides,* which Ridgway (1902) referred to *Phoenicothraupis salvini discolor* (= Red-throated Ant-Tanager) upon re-examination; Gaumer (in Boucard, 1883) reported Red-crowns *(sub nom. P. rubicoides)* following ants in northern Yucatán, but Sclater (1886) referred Gaumer's specimen and his published record to *P. salvini.* Other reports I have read of ant-tanagers at ant swarms all refer to the Red-throated Ant-Tanager subspecies found north from Nicaragua. At Gallon Jug, I saw Red-throats at ant swarms 63 times, the Red-crowns only twice.

Casual foraging by Red-crowned Ant-Tanagers at ant swarms. Time after time, a Red-crown group, chattering and foraging busily, drifted over a swarm that was putting up insects in large quantities. Yet the Red-crowns seemed to take no interest in this abundant supply of food, which was to be had with much less effort than they were expending in their careful search through the limbs. Several times, while Red-throats and other species were busy at a swarm, the Red-crowns and other species of a wandering flock stayed in the vicinity for an hour or more; but members of the wandering flock seldom joined the ant-swarm birds.

At 9 A.M. on 26 April, as I was watching an incubating female Red-crown, an ant swarm passed under her. As the swarm and the ant-following birds moved past, the ants flushed a host of earwigs, which flew all over me in the blind and over all trunks and bushes nearby. As the earwigs alighted near the female Red-crown, she abandoned her quiet pose for a few moments and half rose to pick off all within range of her bill. Her mate drifted by several times as the swarm moved slowly past, and may have captured some of the high-flying earwigs.

My only observation of true swarm-following was on 26 July, when a male and immature male Red-crown came down to a swarm from which a Red-throat group had just departed. For two or three minutes, the Red-crowns and their companions, the Tawny-crowned Greenlets *(Hylophilus ochraceiceps),* chased insects and fluttered from limb to limb less than a meter above the swarm. All drifted off before the Red-throat family returned and did not join the latter at the swarm, though they remained in its vicinity for three hours longer. These

Red-crowns never visited the ground to pick up insects from the middle of the swarm as Red-throats regularly did.

Regular foraging by Red-throated Ant-Tanagers. Despite abundance of food, concentration of birds at the "feeding tables" of the swarms meant increased competition for feeding room. Red-throated Ant-Tanagers were usually present in groups, but individuals generally kept at least one-third meter apart. Many of the infrequent loud sounds from Red-throats at the swarms were rough scolds of displacement or argument. Most of the time the usually noisy Red-throats gave only faint *wik* notes. Some of the scolds followed sudden sounds or movements resulting from falling twigs, passing birds, or my activities.

There was considerable subdivision of the swarm-following niche among Gallon Jug ant-followers. Among them, Red-throated Ant-Tanagers occupied positions at the center of swarm activity, commonly less than a meter above the pillaging hordes. Since swarm ants spread out on a broad front, the major flushing of arthropods was in a zone about a meter deep and five meters wide near the front of each swarm; the ant-tanagers were thus in a good position to intercept arthropods escaping from the ants. The ground was not used for perching; the Red-throats paid only brief visits to it while snapping up insects. The rest of the time they watched from a convenient low twig, fallen log, or other more or less horizontal (rarely a vertical) perch.

The ant-tanagers sometimes stood in the middle of a swarm for several moments while pecking at some insect. But occasional flicks of their wings or sudden leaps of a few centimeters into the air suggested that the tanagers had been victims of sudden ant bites. Red-throats did not react to columns of ants probing along branches hardly a centimeter away, unless such a column flushed some arthropod.

Red-throats were rather active birds when foraging at an ant swarm. They turned from side to side frequently, employing a kind of "rapid peering" (as defined by Grinnell, 1921) in scanning the ground for prey. Such a turn put first one eye and then the other to use in looking at some object. As the tanager turned, its legs seemed to be springs, and the whole body (especially the tail) went down slightly at the center of the motion. From the side, the most noticeable part of the turn was the slight dip of the tail and the change in head position. Such a turning motion was perhaps the most characteristic movement of the ant-tanagers (particularly Red-throats), at swarms or away from swarms. Another common movement was the frequent "about-face," as attention was turned to other sectors of a swarm.

Red-throats darted along low branches, hopping so fast they seemed to be flying, snapping up a blundering moth or beetle at the end of each dash. Now and again, one hopped or fluttered from perch to perch, peering intently down and around so that no suitable prey would escape. The tanager might flutter up and snap an insect off the underside of a leaf, hovering briefly before dropping off and away to another perch, much like a trogon on a fruit-picking flight. Then the tanager would batter the insect energetically and swallow it whole or piecemeal. A few wipes of its bill and the bird would quickly look back to the swarm for a good vantage point. Having detected a roach that was avoiding the army ants below it by running up the stem of a little bush, a Red-throat would hop up a branch, make a lunge, and snap up the insect. Even flying insects, if large and slow, were occasionally snapped out of the air. Several other authors have described similar behavior from ant-tanagers at ant swarms; Sutton's (1951b) descriptions from Gomez Farias, Tamaulipas, at the northern limit of ant-tanager and swarm-ant ranges, agree particularly well with my own observations.

At swarms each Red-throat generally sat with legs spread somewhat apart and tail partly spread. The tail proved a sensitive index to ant-tanager "excitement," being spread wide when one was scolding, but folded, even notched, in quieter moments. The tail and body were usually in line, and the body angled from near or below the horizontal to some 30 degrees above it. Tilt of the body was somewhat indicative of ant-tanager interest in a swarm and food; the birds sat upright during intervals of loafing and preening.

Whenever a swarm reached the edge of an open area, such as a bulldozer trail, the ant-tanagers drifted above the ants out onto projecting limbs along the edge, and often stationed themselves there as the broad front of the swarm moved onward. Their sallies after fleeing insects became longer and longer, and they hesitated only briefly before taking their booty back to the edge of the trail. Finally, perhaps after a brief period of scolding and preening, the tanagers ascended limb to limb on their side and one by one darted down across the trail, often with sudden chatters, to resume feeding above the front of the swarm, now at the other edge of the path. Occasionally, one perched briefly on twigs in the middle of the trail while the front of the swarm crossed. Since the ant swarm moved about 100 meters a day, the crossing of a bulldozer trail two or three meters wide required some 10 to 15 minutes.

Foraging behavior of other ant-followers. The Tawny-winged Woodcreepers, *Dendrocincla anabatina*, usually clung to tree trunks at points slightly higher than the ant-tanagers and from there looked around for flying insects. The woodcreepers were rather successful at intimidation of the other ant-followers, for

even the slightly heavier ant-tanagers usually gave way to them. The woodcreepers picked some insects off the ground and low twigs, and, occasionally, I heard the loud *cherp* of a woodcreeper ring out, followed by a rasping note from an ant-tanager as in a flurry of wings one beat the other to a morsel. However, the insects in the air and on tree trunks, not the ground and twig insects favored by ant-tanagers, were the main food of the woodcreepers.

The third common swarm-follower at Gallon Jug was the Ruddy Woodcreeper *(Dendrocincla homochroa)*. It is interesting that both dendrocinclids followed the swarms while only one ant-tanager did so. Certainly, the Ruddy Woodcreeper's situation otherwise paralleled that of the Red-crowns, for this dendrocinclid, like the Red-crowns, foraged above its sibling, and is as small compared with the Tawny-winged Woodcreeper as are Red-crowns compared with Red-throats.

The third woodcreeper in vertical range at the swarms was the Barred Woodcreeper, *Dendrocolaptes certhia*. This large woodcreeper profited mainly by the occasional columns of ants that ascended trees in the paths of swarms. It took insects mainly off the bark of those trees, even clinging in the midst of ant columns in doing so. It infrequently came low enough to dispute with ant-tanagers, and did not snap up flying insects as often as did the dendrocinclids.

Formicarius analis, the Black-faced Antthrush, occupied yet another swarm-following niche. One or more antthrushes were at every swarm, but instead of waiting in the thick of activity they roamed about on the outskirts of the swarm, particularly behind it, where they flipped leaves over in their usual manner. The advantage of this behavior was obvious; the insects that had escaped from the ants and ant-followers had often taken temporary refuge in places where the antthrushes found them much more easily than on undisturbed areas where the insects had had time to entrench themselves.

Henicorhina leucosticta, the White-breasted Wood-Wren, was the only small resident that was a regular ant-follower. By moving through dense fallen vines in the paths of swarms, this agile hopper took many minute insects the larger birds could not reach.

From February into April, the Hooded Warbler *(Wilsonia citrina)* and the Kentucky Warbler *(Oporornis formosus)* made regular appearances at the swarms, the former capturing small insects from positions near the ant-tanagers and the latter taking small insects from the ground.

A few other species (a tinamou, *Crypturellus boucardi;* a cuckoo, *Piaya cayana;* a woodcreeper, *Xiphorhynchus flavigaster;* two wrens, *Thryothorus maculipectus* and *Uropsila leucogastra;* and a tanager, *Eucometis penicillata*) followed the swarms at times.

Importance of army ant swarms to foraging ant-tanagers. Schneirla *(in litt.)* estimated the abundance of swarm-ant colonies on Barro Colorado Island, Panama Canal Zone, to be about six colonies per 100 hectares (45 colonies each of *Eciton burchelli* and *Labidus praedator* on 14.5 square kilometers as perhaps a safe minimum estimate), whereas six Red-throat groups on my study area occupied about 34 hectares (84 acres). If only half the colonies swarmed on the average on any given day (the fraction is actually more than three-quarters for *E. burchelli*, but may be less than three-quarters for *L. praedator*), and if

ant colonies are as abundant at Gallon Jug as on Barro Colorado, there would be an average of at least one swarm per day for each six tanager groups. The actual ratio may be even higher, as is suggested by the fact that in late July I usually found one swarm for each two or three ant-tanager pairs carefully checked. If there is, on the average, one swarm or more per day for every six ant-tanager groups, in the non-breeding season (when two or three groups sometimes join at a swarm) the tanagers may have swarms to follow as much as half the daylight hours. However, in view of the many variables ignored in the above calculation, quantitative field studies are necessary to determine the fraction of the time during which the territorial ant-tanagers actually are able to follow the wandering army ants.

Swarm ants and ant-tanager distribution. While Red-crowned Ant-Tanagers occur on the Pacific coast of Mexico northwest to Nayarit (Figure 1), Red-throated Ant-Tanagers do not extend farther northwest than the middle of the Isthmus of Tehuantepec. Schneirla *(in litt.)* lists no specimens or observations of the two swarm-ant species on the Pacific coast northwest of the latter area. Apparently, lowland ant-following species other than ant-tanagers are also lacking northwest of this area.

Special Methods of Ant-Tanagers in Foraging for Arthropods

In searching for arthropods, both species of ant-tanagers investigated dried, rolled-up leaves pendent above the ground in the manner of the Worm-eating Warbler *(Helmitheros vermivorus)* in British Honduras, but not so persistently as that species. If poking and inspection revealed prey, the ant-tanager grabbed the whole leaf, perhaps on the wing, trogon-style. With a soft run of conversational notes, the bird then took the leaf to the steady top of a huge palm leaf, the top of a log or large, horizontal limb, or to the ground, and worked the leaf over with its bill, extracting and crushing the insect. Then down went the food whole or bit by bit, and up went the tanager and wiped its bill on a twig.

With swipes of their bills, the ant-tanagers threw dead leaves one way and then the other from the tops of the huge leaves of Bayleaf Palms (*Sabal* sp.), looking carefully after each toss and frequently pecking as if an insect had been uncovered. Araceous and bromeliad epiphytes, whose leaves collected debris, were visited at times, especially if there was enough room for such large and wary birds as the tanagers to work and to make hasty exits if disturbed.

Ant-tanagers generally looked carefully each time an object dropped off a limb or twig when they alighted. On occasion, the tanager darted

downward quickly enough to capture an insect or small twig before it hit the ground. More often, the bird alighted on a bush stem or little branch a meter or less above the spot where the object had hit the ground and scrutinized the area. Leaf-tossing was necessary at times before capture of the arthropod.

The ant-tanagers rarely clung to the underside of a twig or limb in the manner of the furnariid *Xenops minutus,* the greenlet *Hylophilus ochraceiceps,* or the temperate-zone titmice. If some large insect was detected under twigs or leaves from a considerable distance, the ant-tanager would fly up and hover briefly under it, plucking it from the under surface and dropping to a perch to finish it off. Another method of obtaining insects under twigs or leaves, and perhaps the method most often employed by ant-tanagers, was that of perching beside the prey and leaning over underneath the leaf or twig.

Although both ant-tanager species were agile enough to snare some flying insects, they were much less expert than such flycatching birds as the jacamar *Galbula ruficauda,* the shrike-tanager *Lanio aurantius,* the woodcreepers *Dendrocincla anabatina* and *D. homochroa,* and the numerous becards and tyrannids. The ant-tanagers usually depended on seeing where an insect alighted.

Another group that had a different niche from both ant-tanager species were the "trunk-climbers." Although an ant-tanager in its foraging occasionally detected an insect on a large limb or tree trunk and snapped it off clumsily, hovering briefly or partly clinging against the trunk on a vine or epiphyte, in general ant-tanagers paid much more attention to twigs and leaves.

Certainly the ant-tanagers made no attempts to crawl up into the pendent, dead leaves under a huge bromeliad as the Ivory-billed Woodcreepers *(Xiphorhynchus flavigaster)* often did. The ant-tanagers did not examine cracks and crevices in trees as did all eight species of woodcreepers at Gallon Jug, especially for such small insects as those that interested the Olivaceous Woodcreeper *(Sittasomus griseicapillus).* The ant-tanagers were definitely not equipped, as were the Wedge-billed Woodcreeper *(Glyphorhynchus spirurus)* and Plain Xenops *(Xenops minutus)* with their wedge-shaped bills, for poking under lichens or bark strips. The Strong-billed Woodcreeper *(Xiphocolaptes promeropirhynchus)* and the Barred Woodcreeper *(Dendrocolaptes certhia)* probably took more insects of interest to ant-tanagers than any of the other trunk-climbers, but the former was rare in this lowland forest, and both species foraged more on tree trunks and epiphytes than on the twigs where the ant-tanagers did most of their hunting.

Occasionally, an ant-tanager clung to the slender stem of a sapling and peered around, for the moment as deliberate in its motions as a Thrush-like Manakin *(Schiffornis turdinus),* before the resemblance ended when the ant-tanager suddenly darted away. Since limbs were

sparser near the ground, Red-throats might be expected to cling to sapling stems more often than do Red-crowns, but actually both tanagers spent most of their time on horizontal or near-horizontal limbs.

It is possible that the deliberate behavior of *Schiffornis* may have allowed it to detect insects that ant-tanagers overlooked in their rapid travel. It would be interesting to investigate whether such differences in foraging speed, as between vireos and warblers, may result in birds taking different foods. The difference between preferred perching sites (horizontal vs. perpendicular perches) may have allowed *Schiffornis* to detect foods different from those detected by the ant-tanagers.

There seemed to be a slight difference in the way the two ant-tanager species sought insects, a difference that may cause the tanagers to take different foods, even when they forage at the same levels. It was my impression that not only did the Red-throated Ant-Tanagers travel horizontally through the woods, but that they also tended to look horizontally. While Red-crowns did much peering up and down as well as around, the Red-throats seemed to examine more intently the foliage at about their own level. While the Red-crowns often went in any direction for food, commonly the dash of a Red-throat was near the horizontal and often up to a meter or more before the insect was snapped from its hiding place.

Red-crowns often climbed saplings by short hops from limb to limb or by hitching up crosswise, perhaps alternating directions cross-foot style while doing so. More often Red-throats gained height by long flights to distant twigs. At the ends of their climbs, Red-crowns often dropped and flew shrike-fashion to the next tree, whereas Red-throats more often flew directly, more like a jay than like a shrike.

Ant-Tanagers and Fruit

The main zone of the varied and abundant fruit supply of the study-area forest lay above the foraging zones of ant-tanagers, and the high-foraging Red-crowns apparently gained more benefit from the supply than did the low-foraging Red-throats.

Of the favorite fruits of the ant-tanagers during the months I was at Gallon Jug, Bullhoof *(Drypetes Brownii)* and Give-and-Take *(Cryosophila argentea)* lasted the longest. The hard Bullhoof berries had to be very ripe before the ant-tanagers could bite into them, but Red-crown pairs often ascended into Bullhoof trees and fed with saltators, grosbeaks, parrots, trogons, howler monkeys, and other animals much better fitted for eating hard fruits than were ant-tanagers. The first ant-tanager peck at a ripe fruit often sent it hurtling toward the ground, where it was followed hastily by the bird, which there ate the gritty pulp, leaving only one or two white seeds. At other times, the bird pecked at several berries

in succession. Red-throats never joined the flocks in the high trees, but occasionally fed on fruits on fallen branches, and once fed in a tree cut down at the edge of a milpa (corn plantation). In 150 or more hours of observing Red-crowns, I recorded 30 instances when a bird fed on Bullhoof fruit; for Red-throats, there were five instances in somewhat over 53 hours. (Although many instances were not recorded, the fraction recorded should be nearly the same for both species.)

The abundant large clusters of Give-and-Take fruit were already somewhat battered by the time I arrived in February, though the final few to withstand the attacks of many birds lasted well into May. Either species of tanager (49 instances for Red-crowns, seven for Red-throats) now and then fluttered up and picked off a berry, perhaps clinging briefly against the bunch with tail spread wide for support. The bird then took the berry to a perch, where it rotated the fruit with the tongue while biting the thin, stringy flesh off in strips until finally the large seed and part of the pulp dropped from their own weight. After some gulping, the pulp that had not dropped out the corners of the bird's mouth went down its throat. Sometimes, two or three Red-crowns visited the same cluster at the same time. Generally, one or two fruits each were all they swallowed before they moved on restlessly, only to go up to another bunch of fruit a hundred meters farther on and repeat the process.

When the conspicuous orange-red fruit clusters of the wickedly spined climbing palm, Basket Tie-tie (*Desmoncus* sp.), brightened openings in the forest in July, Red-crowns at times clung to a bunch and pecked at a fruit or two before flying on.

In June, as the Bullhoof supply was failing, Cojoton *(Stemmadenia Donnell-Smithii)* fruits attracted parrots and toucans from far and near. Occasionally, their bites sent the fruits plummeting through the limbs; the thud of a baseball-sized fruit beside my blind at one Red-crown nest startled me more than once. After a short time on the ground, each milky, kidney-shaped fruit split down the middle, exposing the seeds in their bright-red, waxy coatings. The incubating female several times made a meal of these seeds at one or more spots around my blind, and several times a day the pair of Red-throats nesting down the hill drifted by and fed on the fallen fruits.

There were many small fruits that both ant-tanagers picked off and ate whole. Among their favorites were the purple berries of Sugarloaf *(Miconia impetiolaris)*, a member of a family (Melastomaceae), much loved by Central American birds (Skutch, 1954) for its juicy berries. Sugarloaf, in fruit during May, was one of the few berry bushes that ever detained a wandering ant-tanager family for more than a few berries: for Red-crowns, 34 instances; for Red-throats, 10 instances. Another favorite (six instances for Red-crowns, 11 for Red-throats), during its week of fruiting in late March, was *Casearia sylvestris*, whose clusters of tiny berries attracted such unexpected species as the flycatchers *Tolmomyias sulphurescens* and *Myiodynastes maculatus* as

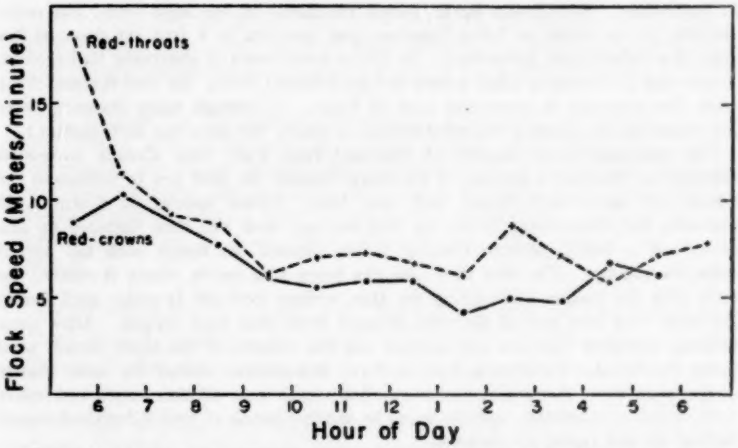


Figure 5. Speed of ant-tanager flock movement when followed (meters per minute). Based on measurements of mapped paths as in Figure 6, for 150 hours' observation of Red-crowned Ant-Tanagers and 53 hours' for Red-throated Ant-Tanagers.

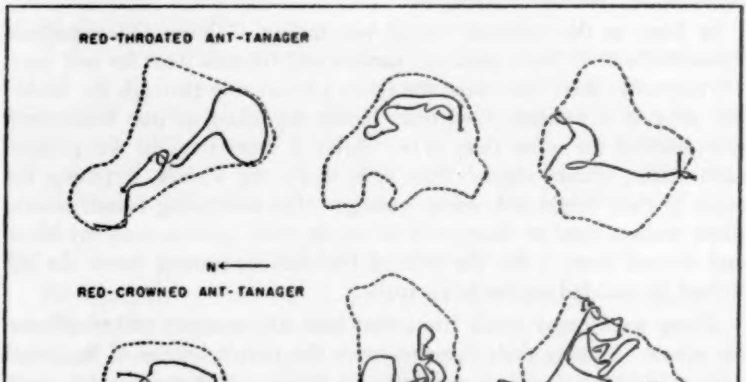


Figure 6. Paths of foraging ant-tanagers, marked at quarter-hour intervals. Broken lines indicate territory boundaries, determined from such maps as these, from records of territorial encounters ("x"), and from nests. Length of N arrow represents 100 meters.

well as the usual fruit-eating birds. In April, the juicy, red berries of the so-called "Cherry" (*Pseudolmedia* sp.) were often taken by the ant-tanagers: there were 45 instances for Red-crowns and 11 for Red-throats. The list could be extended, but the above were the fruits most commonly taken by the ant-tanagers during the time that I was at Gallon Jug.

Ant-Tanager Flock Movement

When foraging, small groups of ant-tanagers moved rapidly (Figure 5) and erratically (Figure 6) through the forest, a type of foraging movement that has led all who know these birds to speak of "wandering bands" and "restless flocks." The average speed of ant-tanager movement (Figure 5), based on measurements of such mapped paths as those in Figure 6, was somewhat greater in Red-throats than in Red-crowns. The former stayed in a narrower stratum and spent less time climbing, but the time saved tended to be used in individual wandering over an area 20 or so meters to either side of a flock's path and so did not bring about an increase in group speed; the greater speed of Red-throat group movement probably reflects instead the greater wariness of Red-throats when followed. The speed of flock movement was greatest in the early morning for both species.

Ant-Tanager Group Composition and Foraging Range

The groups of ant-tanagers were apparently pairs and their grown young of the previous year. With each adult male there was always at least one female, as the ant-tanagers were paired even before the breeding season. A few males were known to be bigamous. The other individuals with each adult male were usually in immature plumage during the breeding season. In late July and August, some of the young males were molting into the red adult plumage. During my stay, the only increases in group size came when the young of the year left the nest; decreases, which were occasional, probably signified the death of birds. Possibly, there may be some permanent shifting of immature birds from one group to another, but this remains to be proved.

At Gallon Jug, even counting young of the year, I never saw a Red-crown group of more than five birds or a Red-throat group of more than eight. Usually, Red-crown groups included two to four birds, while Red-throat groups included up to five. Paynter (1955) noted similar group sizes in Yucatán, and Skutch (1954) got a similar impression of Red-crown groups in Costa Rica.

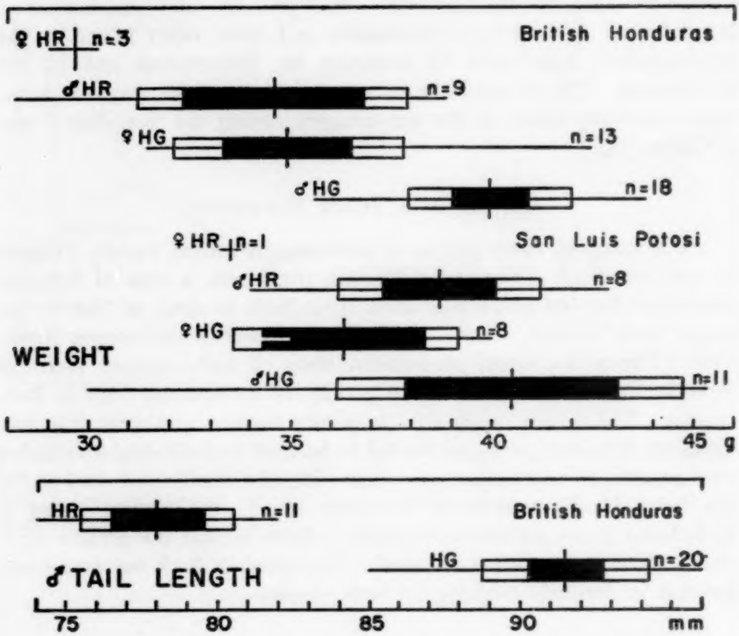


Figure 7. Differences in size of Red-crowned Ant-Tanagers (HR) and Red-throated Ant-Tanagers (HG). Horizontal line—range; vertical line—mean; black bar—two standard errors on either side of mean; open bar—one standard deviation on either side of mean.

In the months I watched them, groups of both ant-tanager species obtained nearly all their food from areas that may be called territories (territorial defense occurred during the nesting period). These were rather large areas of four or five hectares each. At times, a group trespassed briefly into the territory of a neighboring group (Figure 6), but such intrusions were few even before territorial defense began. Before nesting began, two groups of the same species occasionally foraged together, generally along a boundary line, but eventually the groups went back to their respective territories. Red-throat groups were occasionally together at ant swarms near boundary lines before nesting began, but when I scared them, each group darted back to its own area. After nesting began, an ant-tanager group seldom joined another group of the same species while foraging, although females and immatures might forage near each other while adult males disputed

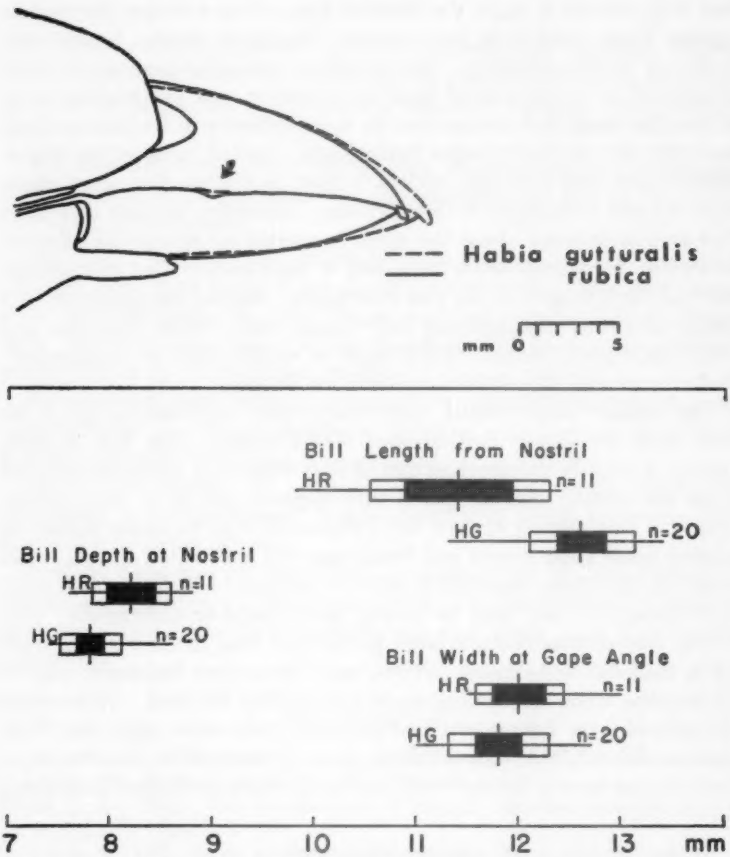


Figure 8. Differences in bill shapes between male ant-tanagers in British Honduras. Note the "tooth" on the bill of Red-crowned Ant-Tanager (arrow). Symbols as in Figure 7. Measurements as in Baldwin *et al.* (1931).

along a territorial boundary. Foraging groups of one species often joined groups of the other species.

Size and Bill Shape in Relation to Food Size

Difference in size, especially of bill, is sometimes correlated with a difference in foraging habits between closely related bird species. Since Red-throated Ant-Tanagers average slightly larger in size (Figure 7)

than Red-crowns, it might be assumed that, on the average, they would capture larger food than Red-crowns. However, several factors cast doubt on this assumption. Ant-tanagers ordinarily tore apart large arthropods or medium-sized fruit by pounding and bill manipulation, so that the small Red-crowns had no more difficulty in consuming large food than did the barely larger Red-throats. Indeed, some of the largest orthopterans and argiopid spiders I saw at Gallon Jug were those captured and torn apart by Red-crowns. Secondly, the fact that male Red-crowns average about the same in weight as female Red-throats in British Honduras seems very odd if interspecific food competition has had much to do with the size divergence. Indeed, the geographically distant and thus noncompeting Red-crowns from British Honduras and San Luis Potosí, Mexico, differ more in weight than do "competing" Red-crowns and Red-throats in San Luis Potosí.

The smaller Red-crowned Ant-Tanager may even take larger foods than does the larger Red-throated Ant-Tanager. The bill of Red-crowns is slightly shorter than that of Red-throats, as might be expected from the smaller size of the former species; yet it is very slightly deeper. This slightly heavier bill (Figure 8) may be better suited for tearing apart large insects and fruits than the bill of Red-throats. The tooth on the upper mandible is more prominent in Red-crowns than in Red-throats; it may help in tearing apart fruits or arthropods. Certainly, Red-crowns brought large particles of food to their young more often than did Red-throats (Willis, ms.), thus more frequently causing an impasse when the nestling could not swallow the food. Red-crowns did dissect large insects and medium-sized fruits more often than Red-throats did while I was watching (but it is possible that the shyer Red-throats merely carried their food away from me before dissection).

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SUMMARY

A study of Red-crowned and Red-throated Ant-Tanagers *(Habia rubica* and *H. gutturalis)* at Gallon Jug, British Honduras, showed some differences in habitat and foraging behavior between these sibling species.

The fact that Red-crowns stay in high forest while the Red-throats are less restricted, foraging in low second-growth as well as high, was confirmed by this study.

The major foraging differences between the two species were that (though both were birds of the forest undergrowth) Red-crowns generally foraged higher than Red-throats and that only Red-throats regularly followed army ants *(Eciton burchelli* and *Labidus praedator),* picking up many of the insects flushed by the ant swarms.

Ant-tanagers used various techniques in capturing arthropods and consuming fruit. Most ant-tanager foraging was done on twigs and branches of trees rather than on tree trunks or in the air.

Ant-tanager groups did most of their foraging while wandering irregularly over "territories," the boundaries of which were defended during the breeding season.

A slight difference in body size is apparently not directly related to differences in foraging; the smaller bird, the Red-crowned Ant-Tanager, may tear apart larger arthropods and fruits with its slightly thicker bill.

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THE INFLUENCE OF WEATHER ON PASSERINE MIGRATION. A REVIEW*

DAVID LACK

INTRODUCTION

THE present review was undertaken as background for my studies (1959a, 1960, and in progress) of migration by radar. I have sought to include all important field observations, published before the end of 1958, on the influence of weather on migration; but as reports of such observations not infrequently occur in papers dealing primarily with other topics, some have doubtless been overlooked. Many trivial and passing references, together with unsubstantiated opinions, have been deliberately omitted. I have, however, included the laboratory studies on migratory restlessness, and, since weather influences cannot be understood apart from the bird's internal state, the latter is also discussed, though not in such detail, owing to the comprehensive review by Farner (1955). I am extremely grateful to A. M. Bagg, W. R. P. Bourne, R. E. Moreau, and A. C. Perdeck for reading and criticizing the whole manuscript and to R. J. Andrew, J. M. Cullen, R. A. Hinde, and N. Tinbergen for detailed discussion of the terminological and other problems connected with the internal state of the bird.

Cooke (1888) was the first to correlate migration, in this case spring arrivals in the United States, with temperature and pressure, and, as pointed out by Bagg *et al.* (1950), his conclusion was essentially correct. The next sustained study appears to have been that of Eagle Clarke (1912), who between 1898 and 1912 visited many islands and lighthouses around Britain to watch migration. He did not publish his data in quantitative form, and evidently did not analyze them statistically; but his conclusions were based on so much intensive field work that most of them are still accepted. He concluded that migration is favored by fine, anticyclonic weather, also by warmth in spring and cold in autumn, while strong winds and rain are unfavorable. What are called "rushes" in England and "waves" in America occur primarily when favorable weather follows an unfavorable spell. Clarke further argued that southeasterly winds favor migration between Britain and the Continent in both spring and autumn, but as suggested by Coward (1912) and established by Williamson (1952, 1955), much of the migra-

* This review of one small aspect of ornithology is dedicated to Prof. Erwin Stresemann, the last man to review all branches of ornithology, on the occasion of his 70th birthday.

tion to Britain with easterly winds is really due to drift. The views of Thomson (1926) were essentially those of Clarke, except that the influence of wind direction was considered doubtful.

In both field and laboratory, nearly all observations on weather and migration have been made on passerine species. Hence the present review is concerned primarily with this order of birds, and, unless specified, general remarks refer only to passerines. Furthermore, all the work reviewed here was carried out in north temperate latitudes, and none in the tropics, for which further information is badly needed.

TECHNIQUES

With the exception of Clarke, the earliest students of the subject, notably Hegyfoky (1908) and Schenk (1924, 1925) in Hungary, Defant (1913) in Austria, Cooke (1913) in North America, and a few others discussed by Thomson (1926), chiefly analyzed dates of first arrival. They considered a great deal of data, and while dates of first arrival are not a very satisfactory way of measuring the volume of migration, many of these early conclusions with respect to the weather are still acceptable.

After this early work, there was a lack of research until, particularly after World War II, two techniques pioneered by Clarke were used extensively. Quantitative observations on diurnal migration in progress were initiated on the Dutch coast by Verwey, followed by Van Dobben, Tinbergen, Deelder, and others (see review by Van Dobben, 1953). Observations were later undertaken at Öland, Falsterbo, and elsewhere in Sweden (see review by Svärdson, 1953) and on a much smaller scale in England (see review by Snow, 1953). In all three countries, detailed studies have been restricted to the autumn, since much less migration is visible in spring. On the basis of this work, Dutch investigators in particular have reached important conclusions on the behavior of migrants, notably with regard to coasting. But in assessing the influence of the weather on migration, this technique has an exceedingly serious drawback, since birds often migrate by day above visual range, and the proportion doing so varies with weather and other factors. To cite an extreme example from my radar work in Norfolk in April 1958: On those mornings on which radar detected a large seaward emigration, many migrants were visible from the ground with opposing winds, whereas none, or hardly any, were visible with following winds (Lack, 1960).

The second technique is the regular counting of night migrants on the ground by day after their passage. This has been undertaken, espe-

cially in the United States, chiefly in spring but also in autumn (Bagg *et al.*, 1950, and others cited later), and at British coastal and insular bird observatories, chiefly in autumn but also in spring (Williamson, 1955, and various writers in "British Birds," *seriatim*). This method has yielded valuable conclusions on diverse topics, but for analyzing weather influences, it likewise suffers from serious drawbacks. First, since it is the weather at the point of departure that is critical, an important step in the argument, namely the place of departure of the observed migrants, has to rest on inference. Probably the inference has often been correct, though some doubt must always remain, while occasionally it would seem to have been incorrect. Second, if the migrants are liable to drift off course, they may have started from different areas on different occasions, a difficulty that applies particularly to insular and coastal observatories. Here, for instance, the presence of migrants from a particular area on one day and their absence on another might be due, not to differences in the weather at the place of origin, but merely to the direction of the wind on their journey. This, as already mentioned, misled Clarke (1912); and Svärdson (1953) could still claim that, because of this effect, British observers exaggerate the importance of easterly winds for migration. Drift may be as prevalent over the land as over the sea, but is probably a less-serious source of bias. Its importance in continental United States was shown by Trowbridge (1895); see also Peterson (1948: 161–163) and Bennett (1952).

Third, and most serious, the number of night migrants alighting need not be proportionate to the number that passed overhead. Lowery (1951) cogently argued that concentrations of night migrants occur on the ground only at a meteorological barrier or in an "oasis" of suitable habitat (including islands). Hence "rushes" or "waves" of night migrants may provide a misleading idea of normal migration. On a continent, such "rushes" are chiefly precipitated by the rain and mist at a cold front (*e.g.*, Imhof, 1953; Bagg, 1956, 1957), while on islands, they also occur when birds have previously been drifted a long way off course over the sea. The belief that the number of migrants alighting may represent a highly variable proportion of those passing overhead was supported by my radar observations in autumn in Norfolk: Four times in September 1958, radar revealed fairly large, southwestward arrivals of night migrants, after which, respectively, many, some, very few, and none were seen in the bushes at Blakeney Point. Clearly, it is dangerous to base conclusion as to the volume of migration passing overhead on the number of night migrants seen on the ground next day. Nevertheless, especially when its limitations are recognized, this method has yielded valuable results, as shown, for instance, by Bagg *et al.*

(1950) in the United States, while British observatory investigators have analyzed the weather conditions favoring drift (Williamson, 1955).

Recently, two new techniques, which do not suffer from the above defects, have been employed to measure the volume of migration. Lowery (1951; Lowery and Newman, 1955) counted night migrants crossing the face of the moon, and from this count calculated the true numbers passing. This method permitted direct quantitative observations on night migration for the first time, but it is usable only on clear, moonlit nights, so has limited application to the problem reviewed here. Still more recently, Sutter (1957a,b) established the value of radar, and while the density of echoes cannot be related to the true number of birds flying, radar provides a relative measure of abundance that can be used all day and all night, only those migrants flying very low being undetected (Lack, 1959a). Species cannot be identified by radar, though identification can sometimes be inferred. But while this limitation must be kept in mind, it may not greatly matter in the present context if, as seems possible, most passerine species have rather similar responses to weather. The last point needs checking. For the present, the best method is probably radar combined with visual observations.

After a reliable quantitative record of migration has been obtained, it is important to analyze it in terms of all the likely weather factors by a multiple regression equation, and, for statistically significant results, a large series of observations may be required. What has sometimes been done is to examine the possible influence of one weather factor in isolation; but since the various weather factors are usually linked, this can be very misleading. When all the factors favoring migration tend to occur simultaneously, as for birds crossing from Holland to Britain in October, it may be particularly hard to tell which are critical and which coincidental. There is the final difficulty that the effects of the weather are probably not constant, but may well vary with the internal state of the bird.

In the laboratory, one further technique has proved valuable, namely the observation of migratory restlessness *(Zugunruhe)*. The review by Farner (1955) leaves no serious doubt that migratory restlessness can be regarded as the laboratory equivalent of migration itself. In captive passerines, it is not shown by nonmigratory but is highly characteristic of migratory forms. Further, in untreated birds, it normally starts in spring and ends in autumn at the same times as the normal migrations of the species. It is true that, as found by various investigators, the latest being Weise (1956), restlessness may continue throughout the summer, long after the normal cessation of spring migration, and stop only with the molt. But it may reasonably be inferred that this is be-

cause the captive birds have been unnaturally prevented from breeding. This view is supported by observations (Kay, 1944) on a pair of captive Snow Buntings *(Plectrophenax nivalis)* in a big outdoor aviary, which showed migratory restlessness only until the male, and 15 days later the female, switched to breeding behavior; the female paid no attention to the male's courtship until she too had, so to speak, "arrived," and then the pair bred successfully. Also, Wagner (1957b) showed recently that gonadal hormones may inhibit migratory restlessness in summer.

Migratory restlessness therefore provides an important means for testing the influence of both external and internal factors on migration. Further, it can be recorded automatically, and though in some early studies it may not always have been clearly separated from other forms of restlessness, this difficulty has been overcome (cf. Wagner, 1957a). Moreover, the directional element investigated by Kramer (1957) and Sauer (1957) now provides an additional criterion for its recognition.

Climate as an Ultimate Factor

In general, the spring migration of each species appears to be so timed that the birds arrive on their breeding grounds at almost the earliest moment that they have a reasonable chance of surviving there. In many species, especially in the far north, this is only a few days before breeding starts, but in many others, especially in temperate latitudes, the birds may arrive well before breeding, in order to establish territories and form pairs. The Robin *(Erithacus rubecula)* in England is a good example of the latter group, those females that are migrants arriving to form pairs with the resident males some two-three months before nesting (Lack, 1943). Again, the autumn migration of most species appears to be so timed that the birds leave their breeding grounds ahead of the period when their continued survival there would be precarious. Some species leave well before this time, others only shortly before, depending on the molt, and on feeding conditions along the migratory route and in the wintering grounds. There are also a few species that depart only when survival becomes precarious, as discussed later under hard-weather movements.

Both the date in spring when it becomes possible to settle on the breeding grounds and the date in autumn or winter when survival there becomes precarious depend especially on the availability of food, which in turn depends greatly on day length and climate. In this sense, climate has an important influence, through natural selection, on the seasons of migration that have been evolved by each species; but as stressed by several recent authors, this does not necessarily mean that the migrants

in question respond directly to those weather factors that are critical for their survival. In particular, as just mentioned, they usually leave in autumn before the time when survival would become precarious.

In this ultimate and long-term sense, the influence of the environment on migration will not be considered further here, except for one set of observations, the significance of which, though appreciated by their author, has sometimes been misunderstood by others. Using the method pioneered by Cooke (1913) in North America, Southern (1938–1941) plotted on maps of Europe the mean dates on which various summer visitors first arrived, and showed that these "isochronic" lines move northward in spring more or less in parallel with the mean isotherms. All that this implies is that temperature gives a good indication of the season at which each area normally becomes suitable for the species in question to settle on it for the summer. It does not necessarily mean that the species migrates in direct response to temperature, and it certainly does not mean that individual migrants travel northward at the slow speed of the "isochronic" lines. The last point was demonstrated for the Yellow Warbler *(Dendroica petechia)* by Phillips (1951) in Arizona, where the earliest race to arrive, in mid-March, is the summer resident *sonorana*, while more northern races do not reach Arizona until late April, and the northernmost *rubiginosa* not until late May or even June; *i.e.*, the northern forms pass through Arizona later than the southern forms. Bourne *(in litt.)* found a similar situation for Yellow Wagtails of the *Motacilla flava* complex in Cyprus. The first to arrive there in spring is the resident *feldegg*, later come members of *flava* itself and its close allies, which breed farther north, while the last to come is the arctic-breeding *thunbergi*. These forms leave the wintering grounds in tropical Africa in the same order (Curry-Lindahl, 1958).

The influence of climate on the evolution of migratory seasons is indirect, through its effect on the times when the breeding grounds become suitable for occupation in spring or unsuitable for survival in autumn. But the possibility has been raised by Williamson (1953) that climate may sometimes have had a more direct influence, migratory seasons having been evolved to coincide with those times that, on the average, are favorable for travel, and to avoid those times that, on the average, are unfavorable for travel. He advanced this view particularly because small passerine migrants leave northern Europe rather early in the autumn, when the Azores high tends to prevail in the Atlantic and the subtropical high in the Mediterranean, and before the period of disturbed weather that typically follows. Geese, in contrast, tend to leave later, perhaps partly in correlation with their breeding season and molt, and because, being stronger fliers, they are less affected by disturbed weather. This interesting idea remains speculative. I think it more likely that the passerine populations concerned have evolved their migratory seasons primarily through ecological considerations, especially those affecting their food supply on their breeding or wintering grounds or between the two. But this view is equally speculative.

Obviously, however, birds cannot migrate under very hazardous weather conditions, and natural selection may, perhaps, in some species have affected the average season of migration to at least this minimal extent.

Landsberg (1948) suggested that the times and routes of migration of diverse species have been evolved to take advantage of following winds for their journey. He was primarily concerned with nonpasserine, long-distance migrants, but the same correlation was also suggested by Williamson (1953) for passerine migrants travelling from Greenland and Iceland to western Europe in autumn. That Wilson's Petrel *(Oceanites oceanicus)* and the Greater Shearwater *(Puffinus gravis)* tend to migrate with the wind was earlier pointed out by Bourlière (1946), and later for various other species of petrels by Kuroda (1957). These species travel great distances so that, though they are capable fliers, the evolution of their routes might conceivably have been influenced by wind direction. Even so, however, I would suppose that ecological considerations, especially of food supply, are more likely to have been the overriding factor. For passerine species, nearly all of which travel much shorter distances than these petrels, I would think that ecological conditions would always be paramount. Bagg and Drury *(in litt.)* have suggested to me, however, that the seasons of migration in passerine species may have been selected in relation to travelling conditions in areas where seasonal changes in climate are relatively uniform and predictable, as in much of continental North America. My thinking on this point has perhaps been unduly swayed by the highly variable weather prevailing on the Atlantic seaboard of western Europe. Further study of this point is needed.

Weather Making Migration Conspicuous

It is important to distinguish the influence of weather in initiating migration from its influence in making migration conspicuous. As already mentioned, night migrants are precipitated by cold fronts and their attendant rain. In spring in northern Alabama, for instance, the average number of transient night migrants seen on the ground each day was nearly twice the average for the season with a cold front, about average with adverse winds, somewhat below average with southerly (following) winds or with rain unassociated with a cold front, and far below average on the few clear and warm days in the series observed (Imhof, 1953). Yet the last type of weather is generally accepted as being that most favorable for migration. Again, of six big groundings of night migrants in Texas, five occurred with cold fronts and northerly winds and one with a westerly wind (Dennis, 1954). Other good

examples were given by Bagg (1956, 1957). With a cold front, night migrants continuing their flight evidently travel lower than usual, and they may be attracted to the lights on buildings, with the results that many may then be killed at airport ceilometers or television towers. There seem to be no records of this in Europe, a point deserving further study, but many in the United States (*e.g.*, Brewer and Ellis, 1958); the record ceilometer kill was 50,000 individuals of 53 species on the night of 8 October 1954 (Johnson and Haines, 1957). Night migrants are also attracted to lighthouses in rain or fog (Clarke, 1912) and may descend in large numbers on British islands or headlands in any type of weather after a long, overseas drift (Williamson, 1955; see also Lack, 1959b).

With regard to day migrants, adverse weather factors over the land usually inhibit migration altogether. But with strong head winds or rain, the birds sometimes fly lower without stopping, and thus come within visual range of an observer on the ground (Sutter, 1955; personal observations in England and southern France). The old belief that migration normally proceeds against the wind (cf. Gurney, 1923) is partly attributable to migrants flying lower against the wind, and so being more conspicuous. The fact that diurnal migrants may fly extremely high with a following wind was first demonstrated by Kramer (1931) and later proved for the Chaffinch *(Fringilla coelebs)* by the Dutch (review by Van Dobben, 1953).

The subject of the present section will not be considered further as it was included only as a warning, and the weather factors initiating or determining migration will now be reviewed.

General Weather Situation

In the United States in spring, nocturnal migration occurs chiefly in warm weather with southerly winds, commonly with a tropical airstream in the western part of an area of high pressure, and in the interval between a warm and a cold front, *i.e.*, the warm sector of a low-pressure system (Bagg *et al.*, 1950; Lowery, 1951; and others cited later). Likewise in Austria (Defant, 1910, 1913) and Hungary (Hegyfoky, 1908; Schenk, 1924, 1925), most migrants arrive in spring with warm, southerly or southeasterly winds, with high pressure over the Balkans and low pressure to west or northwest. In Scandinavia also, most migrants arrive with warm, southerly winds (Svärdson, 1953). In autumn, on the other hand, most migration in the United States occurs with cold, northerly winds, especially with the passage of a cold front (Bennett, 1952; and others). In Scandinavia in autumn, most noc-

turnal migrants depart in fine, anticyclonic weather with clear skies, light, easterly winds, and a fall in temperature, and the same holds for movements from Germany or Holland to Britain in autumn (Clarke, 1912; Jenkins, 1953; Griffin *et al.*, 1955; Nisbet, 1957a). But "rushes" or "waves" by day in Scandinavia are usually associated, not with anticyclones, but with the northwesterly winds and the drop in temperature characteristic of the hindside of a depression clearing toward the east or northeast (Svärdson, 1953; Nisbet, 1957a).

The usual view today is that migrants do not react to the general weather situation as such, but to one or more particular factors linked with it. The only recent authority to dissent from this view was Nisbet (1957a), who found that in autumn in Scandinavia "the general characteristics of the weather on the days of complete inhibition [of migration] varied considerably. . . ." This "suggests that the important factor may be cyclonic weather as such: that the birds do not react to the individual factors, either singly or in combination, but to a complex system of changes." Nisbet treated the situation solely from the viewpoint of bad weather acting as a deterrent, without refuting the alternative viewpoint that favorable weather factors might provide a positive stimulus to migration. Also, while he doubtless had more evidence than he published, he did not, in my view, convincingly distinguish his postulated response to the general weather situation from a response to separate weather factors, any one of which might deter migration. Nor did he meet the point made by Svärdson (1953) that in Scandinavia the actual weather associated with anticyclones and cyclones, respectively, varies so greatly in character with the time of year that it seems extremely unlikely that migrants are responding to the general weather situation as such (and Svärdson suggested that temperature was the critical factor).

Finally, my own findings (1960) based on radar show that the general weather situation as such had no important influence on the eastward emigration in spring from Norfolk in 1956–1959. In particular, the mean volume of emigration was the same for all anticyclonic periods on the one hand and for all periods of disturbed weather on the other. This was because, in March and April, anticyclones bring some factors (*e.g.*, clear skies and light winds), which, as will be shown later, are favorable to migration, and others (*e.g.*, cold), which are unfavorable to migration in spring. Similarly, disturbed weather brings some adverse factors, such as rain, cloud, and strong winds, but one favorable factor, warmth. Analysis made it clear that the volume of emigration was determined by these particular weather factors and not by the general weather situation as such.

In the reverse passage from Holland to Norfolk in autumn, all the particular factors favoring migration normally occur with anticyclonic weather and all those unfavorable to migration with cyclonic weather, so it has not yet been possible for me to separate their influence from that of the general weather situation. For the same reason, it was not justifiable for Williamson (1952, 1955) to conclude that the primary factor stimulating autumn migration in northwestern Europe is neither anticyclonic weather as such, nor cold, but the absence of wind, and also clear skies, since all these factors normally occur together in autumn, and he did not separate their effects, at least in his published papers. In most other areas in both autumn and spring, published data suggest that the factors favoring migration usually occur together, as do those unfavorable to migration, thus making analysis very difficult. This also raises the possibility that if all the factors favorable for migration normally occur with one type of weather situation, the birds might evolve a response to one "key" factor indicative of this situation. In particular, this may be why various migrants have an immediate response to temperature, as discussed later.

In summary, it can be stated that while most of the available evidence is inconclusive, that of Svärdson (1953) in autumn from Scandinavia suggests, and my own in spring from Norfolk establishes, that the general weather situation does not, in itself, have an important influence on the volume of migration.

Barometric Pressure

No recent investigator has claimed that barometric pressure as such has an important influence on migration, and those who specifically investigated it, such as Mascher (1955) in spring in Sweden and Raynor (1956) in spring in the United States, declared that it had no influence. Further, if the general weather situation has no influence, as concluded in the last section, it follows that atmospheric pressure has none. Finally, apart from some early claims not since substantiated, students of migratory restlessness have found that air pressure had no influence (Merkel, 1938; Wagner, 1957a; and others).

Hence the tendency for migration to occur chiefly in anticyclonic weather can safely be attributed to factors other than high pressure, and in particular to the concurrent light winds, clear skies, and, in autumn, cold. It should be added, however, that while in some areas at some seasons most migration occurs when pressure is high, notably in northwestern Europe in autumn, this correlation is by no means so general as some writers have implied. In particular, the emigration of

winter visitors from England in spring is as frequent in rather disturbed, southwesterly weather as in anticyclonic weather (Lack, 1960). Likewise, most northward migration in eastern North America in spring occurs not in anticyclonic weather but in the warm sector of a depression (Bagg *et al.*, 1950; Gunn, 1958).

STABLE AIR

One investigator, Raynor (1956), claimed that the essential prerequisite for nocturnal migration in spring in the United States is stable air conditions, *i.e.*, with a temperature inversion. Such conditions obtained on 67 per cent of the many nights analyzed, whereas 76 per cent of the migratory movements and 86 per cent of the big waves of migration occurred with stable air. He postulated that stable air itself provided the stimulus, rather than some other weather factor linked with it, and that this was of value because, in stable air, the migrant does not have to expend so much energy combating air turbulence and keeping direction. He further postulated that the migrant is sensitive to a smooth air flow, and perhaps, as it rises up in the evening, to the changes in temperature that it experiences with height.

Although Raynor examined other weather factors, he did not make clear the extent to which they were correlated with each other, and he differed from other American observers in finding temperature unimportant. I therefore suggest that his figures might be re-analyzed, to see whether they are explicable in terms of wind strength, temperature, rain, and cloud, and that until this has been done, his conclusions should not be accepted. It may be added that, while on general grounds one might expect birds to avoid migrating in turbulent air, temperature inversions, at least around the North Sea, are often associated with mist or fog, which is unfavorable to migration.

MIST, CLOUD, AND RAIN

All authorities have agreed that migration is favored by clear weather, while fog, mist, and rain are unfavorable, and though statistical evidence is in most cases lacking, this conclusion can be accepted. The paucity or absence of migration in mist or rain has been reported in the following instances: the spring migration of ducks in Finland (Bergman, 1941), the spring return to Sweden of the Wood Warbler *(Phylloscopus sibilatrix)* (Svärdson, 1947) and various other passerine species (Mascher, 1955), the autumn passage of the Red-breasted Nuthatch *(Sitta canadensis)* in the Gaspé Peninsula (Ball, 1947), the diurnal movements of passerine migrants in spring in Suffolk (Ticehurst, 1932),

and the diurnal movements of passerine species in autumn at Land's End (Lack and Lack, 1952) and in southwest Scotland (Goodbody, 1956). Further, rain and cloud inhibited the migratory restlessness of captive Snow Buntings *(Plectrophenax nivalis)* in an outdoor aviary (Kay, 1944), while Sutter (1957a,b, 1958), using radar, showed that autumnal migration did not normally occur in Switzerland in cloud or high fog, though it continued above fog up to 400 meters.

Finally, in my own studies (1960) of the spring emigration from Norfolk, a multiple regression analysis showed that, making full allowance for other factors, both rain and cloud had a significant effect in reducing the volume of seaward emigration. Further, when the emigration concerned was localized, this was normally correlated with rain in those areas from which no emigration took place.

A point requiring further study is the extent to which species differ in their response to rain. Thus, in both England and southern France in October, I have seen Chaffinches *(Fringilla coelebs)* migrating in large numbers during heavy rain when Skylarks and Starlings had ceased to travel.

With regard to behavior in fog, it is well known that migrants may then become disoriented, while they are attracted to lights. On foggy mornings at Land's End in October, I saw Skylarks *(Alauda arvensis)* repeatedly rising off the fields in the early morning as if to start on migration but then returning and alighting, evidently because of the fog, since when the fog lifted some of them departed. Also at Land's End I saw a huge flock of Starlings *(Sturnus vulgaris)* put out to sea in the direction of Ireland; but a short time afterwards some of them returned, presumably because they had encountered a patch of drizzle visible from the shore (Lack, 1952). Ticehurst (1932) saw various diurnal migrants setting out to sea from Suffolk in spring and returning because they had met fog or rain, and I (1960) have seen the same in Norfolk in spring. Since Kramer (1957) and Sauer (1957) showed that sight of the sun and stars is needed for orientation, one would expect migrants not to set out in total overcast, and to return to land on meeting total overcast at sea.

Nevertheless, the volume of high, seaward emigration tracked by radar from Norfolk in spring was not lower than usual with coastal fog, presumably because the migrants in question started inland in clear weather and flew above the fog out to sea. As already mentioned, Sutter likewise observed migration above low fog in Switzerland, while on one spring morning in Norfolk I tracked migrants arriving northwestward, presumably from the sea, which continued their flight over the land keeping above a belt of fog at a height of 1,200–1,600 meters. More remarkably, both Ash and Schifferli (cited in Lack, 1959b) have trapped migrants on passage that were released by day in fog and promptly flew vertically upward, presumably to continue their migration above the fog.

Complete cloud cover does not necessarily bring migration to a stop. If passerine migrants meet clouds at sea, they must continue, and they may also do so over the land. Thus, a statement by Tinbergen (1956) on orientation implies that there is a considerable diurnal passage of Chaffinches over Holland in autumn in

fully overcast conditions. Again, Bagg *(in litt.)* informed me that in Massachusetts in spring in warm sector conditions involving complete overcast, he has often observed significant diurnal passage in raptors, American Robins *(Turdus migratorius)* and American blackbirds *(Icteridae)*. This subject needs further study.

WIND STRENGTH

It is generally agreed that light winds are favorable and strong winds unfavorable for migration. This was reported in the spring for the White Stork *(Ciconia ciconia)* in Hungary (Hegyfoky, 1908), for ducks in Finland (Bergman, 1941), for Chaffinches in Finland (Bergman, 1949), for many other small passerine species in Finland (Bergman, 1951), and for many passerine night migrants in Sweden (Mascher, 1955). Likewise in autumn, it was found for visible passerine migration in Britain (Lack and Lack, 1952; Goodbody, 1956), for many small passerine species in Finland (Bergman, 1951), and for night migrants in southwestern Europe (Jenkins, 1953), while, as already mentioned, Williamson (1952, 1955) attached particular importance to the absence of wind in initiating migration, though he did not publish critical evidence. Finally, my own (1960) radar studies of the spring emigration in Norfolk established statistically that more emigration occurred with light than strong winds; contrary to a preliminary statement (Lack, 1958b), the effect of the wind now proves to have been similar by night and day.

As in the case of rain, further work is needed on possible specific differences in the response to wind. Goodbody (1956) observed in southwest Scotland in autumn that, when the wind reached a certain strength, Skylarks continued to put out to sea, but Meadow Pipits *(Anthus pratensis)* ceased to do so. My own observations in southern England in October showed that migrating Chaffinches usually ceased travelling at a wind strength that did not deter Starlings and Skylarks.

WARMTH IN SPRING

In both Europe and the United States, nearly all investigators have agreed that spring migration is favored by warm, southerly winds. While this observation does not enable one to say whether it is the temperature or the wind direction that is critical, it strongly implies that at least one of them is important.

In Europe, arrivals with warm, southerly winds were recorded for the Swallow *(Hirundo rustica)* in Hungary by Hegyfoky (1908) and for a variety of passerine night migrants in Sweden and Finland by Rudebeck and Svärdson (1946), Svärdson (1947, 1953), Ulfstrand (1952), and Mascher (1955). In the spring of 1950, correlated with a marked difference in temperature to the southeast and southwest of

Sweden, respectively, migrants coming from the southeast were unusually early and migrants coming from the southwest were unusually late (Ulfstrand, 1952, who recorded the biggest arrival with a warm front). Rudebeck and Svärdson (1946) also stressed that the critical temperature is not that in Sweden itself but that in the area from which the migrants have come. Mascher (1955) noted that arrivals were most numerous just after a rise in temperature but decreased after a few days even when the temperature remained high, supposedly because the supply of birds in the south had become temporarily exhausted. Contrary to the findings of these observers, who stated or implied that arrivals occurred on the first day of warm weather, Bergman (1941) discovered that in Finland ducks migrated earlier in a warm than a cold spring, but that day-to-day changes in numbers were not correlated with changes in temperature. Later, working with many species, chiefly passerines, Bergman (1951) found that a rise in temperature in spring was usually followed by an arrival of migrants.

In Britain, Clarke (1912) stated that spring emigration was favored by warm, southwesterly weather, though it also occurred with anticyclones, which are normally cold. Hinde (1951) found that arrivals of terns and limicoline species in England in spring were associated with warm weather in the Bay of Biscay on the day of their arrival or on the previous day. The only factor seriously delaying the return of Swifts *(Apus apus)* to England in spring was found to be cold, anticyclonic weather with northerly winds. Other evidence strongly indicated that this species was not deterred by anticyclones or head winds as such; thus cold, which in this species directly affects the availability of food, was presumably the critical factor (Lack, 1958a). Finally, my observations by radar (1960) on the emigration from Norfolk in the spring of 1956–1959 showed that, when allowance had been made for other weather factors, warmth was favorable and cold unfavorable to emigration, the effect being statistically significant. The figures further suggest that the lower limit of temperature at which emigration occurred on an appreciable scale was some 10 degrees lower in March than February, and still lower in April. Hence, as found previously by Nice (1937), temperature had an obvious influence in the early but not the late spring.

In the United States, Cooke (1913), analyzing dates of first arrival over 10 years, found a tendency for northward movements to occur with rising temperatures. But a detailed analysis of three years showed that in 1885 two migratory waves coincided with warm spells but one with a cold snap, and though in 1889, movements generally coincided with warm weather, in the late spring of 1892, migrants arrived later than usual at below-average temperatures. In general, birds arrived in a wide variety of temperatures. This does not, however, mean that temperature is unimportant. In particular, in 1892 the birds were unduly delayed by the cold weather, and they eventually travelled despite it, not because of it, as I (1960) likewise found in the cold late spring of 1958 in Norfolk. Unusually late arrivals were likewise characteristic of the spring of 1958 in the eastern United States and Canada, when anticyclonic weather with cool, northerly winds prevailed, and the usual warm, southerly winds were absent (Gunn, 1958).

In the Song Sparrow *(Melospiza melodia)* and other species in Ohio, Nice (1937) found that a high temperature was the chief factor influencing arrivals in the earlier but not the later part of the spring. In other parts of the eastern United States, Gunn and Crocker (1947) correlated an exceptionally early spring arrival with warm, southerly winds, Williams (1950) associated big rushes in spring with high temperatures, Bagg *et al.* (1950) found that most arrivals

occurred with southerly winds, especially with tropical air (see also Bagg 1956, 1957), Dennis (1954) found that most northward departures from Texas took place in warm weather with southerly winds, and Devlin (1954) similarly associated the spring migration through Philadelphia with southerly winds, which are warm. Moreover, Bagg *(in litt.)* has found that under such conditions typical nocturnal migrants may continue travelling by day, which does not normally happen under other weather conditions in spring. As already mentioned, Raynor (1956) differed from other American investigations in finding no relation between northward night migration and rising temperatures in spring; but, particularly in regard to his finding that southerly winds had an influence, I suggest that his data should be re-analyzed.

Cold in Autumn

In eastern Canada, Ball (1947) found that temperature had no influence on the movements of the Red-breasted Nuthatch *(Sitta canadensis)*, but this was in July and August, and cold seems chiefly to influence migration in the latter half of the autumn. In the United States, nocturnal movements in September normally occur with cold, northerly winds, especially with cold fronts (Bennett, 1952; Lowery and Newman, 1955), but the difficulty, as in spring, is to separate the possible influence of temperature from that of wind direction.

Bagg *(in litt.)* has added three points. First, following a sharp drop in temperature in fall, typical nocturnal migrants sometimes continue migrating at tree-top level by day, as they also do with a warm front in spring. Second, the diurnal migration of the Broad-winged Hawk *(Buteo platypterus)*, expected through the northeastern United States between 10 and 25 September, comes early if there is a sharp drop in temperature early in this period, while later it is set off by a smaller drop in temperature, and later still, may occur if there has been no drop in temperature. Third, while nearly all cold fronts in fall are associated with a wind from between northwest and northeast, the front rarely moves eastward faster than the associated low center, and then the wind blows from the southwest; but the migrants set off nevertheless, thus demonstrating that the low temperature and not the following wind of the cold front is the critical factor.

In Finland, the last of five big night movements of thrushes (*Turdus* spp.) in autumn coincided with a marked drop in temperature (the others with falling pressure) (Siivonen, 1936). Haartman and Bergman (1943), studying a variety of species, found that only a small proportion of autumn departures were associated with cold, but later, Bergman (1951) found that a fall in temperature preceded the departure of many species, chiefly passerines. On the other hand, the departures of Waxwings *(Bombycilla garrulus)* from Scandinavia in

autumn did not occur with a drop in temperature but at temperatures normal for the time of year (Ritchie, 1940). Jenkins (1953), however, showed a strong connection between the departures of night migrants and a drop in temperature in Scandinavia in the autumn of 1951. So, much earlier, did Clarke (1912) and Ticehurst (1932) for both day and night migrants from the eastern side of the North Sea in autumn. I have been finding the same in studies by radar for the westward movements by day and night from Holland into Norfolk in autumn. But in all these cases, the drop in temperature has also been associated with anticyclonic weather, clear skies, and light, easterly winds, so that it has not yet been possible to separate the effect of temperature from that of other factors. As regards diurnal movements in Sweden, Svärdson (1953) showed that all the big avalanches through Öland occurred with a drop in temperature in the presumed area of origin of the migrants, especially with polar air in the cold sector. Indeed, he stated that a drop in temperature was the one factor common to all observed movements. Finally, Barnes (1956) associated the unusually delayed departures of many summer residents from Britain in the autumn of 1954 with the unusually mild weather that prevailed. Hence, while a clearer analysis is desirable, it seems probable that cold is often, though not always, important in initiating autumn migration.

HARD-WEATHER AND REVERSED MIGRATIONS

In northwestern Europe, the main autumn migration ceases in about mid-November, but movements in the same directions are resumed if there is a sharp cold spell. Such "hard-weather movements," like true autumn migration, usually occur in anticyclonic weather with light, easterly winds, and no clear line can be drawn between the two. The chief difference is that true migration occurs every autumn, whereas hard-weather movements take place only if there are cold spells. Indeed, such movements occur even after the start of the return migration in spring if cold weather supervenes, though they are then usually called reversed migration *(Rückzug)*. Since they may occur with hard weather at any time during the winter and early spring, it seems likely that the birds concerned do not build up peritoneal fat stores beforehand; and if they do not do so, this constitutes another difference from true migration.

In some of the populations concerned, such as those of the Starling and Lapwing *(Vanellus vanellus)*, it would seem that some individuals regularly migrate, while others move only if there is later hard weather. In some species, too, there are movements throughout the winter and early spring, southwest with each cold spell

and northeast with each warm spell, as shown for the Skylark *(Alauda arvensis)* by Drost (1929), the Lapwing by Klomp (1947) and especially Vleugel (1948), and the European Golden Plover *(Charadrius apricarius)* by Vleugel (1948). Hard-weather movements are also found in various European ducks (Schüz, 1952), while the Chaffinch *(Fringilla coelebs)* is especially liable to reversed movements after its return to Fenno-Scandia in spring (Swanberg, 1948; Bergman, 1949; Westernhagen, 1953). As pointed out by Svärdson (1953), temperature appears to have a directional effect on migration in spring, since warmth sends the birds northeast and cold southwest; in autumn, on the other hand, unusual warmth does not stimulate northward movements, though it may delay southward departures. While the southwestward movements in winter occur with hard weather, further analysis is needed to determine whether the critical factor is low temperature as such, or whether snow, frost, or actual shortage of food plays a part.

Temperature and Migratory Restlessness

The strong presumptive evidence that warmth stimulates migration in spring and cold in autumn is reinforced by the laboratory observations on migratory restlessness.

A sudden and substantial rise in temperature in early spring induced migratory restlessness in a caged Robin *(Erithacus rubecula)* (Palmgren, 1937; and doubtfully Schildmacher, 1938). Again, Weise (1956) found an increase in migratory restlessness in warm weather, including warm fronts, and a decrease in cold weather, including cold fronts, in the White-throated Sparrow *(Zonotrichia albicollis)*, Slate-colored Junco *(Junco hyemalis)*, and American Tree Sparrow *(Spizella arborea)*, kept in outdoor aviaries in spring. Likewise, in the White-crowned Sparrow *(Zonotrichia leucophrys)*, earlier experiments suggested that a rise in temperature produced both nocturnal restlessness (Farner and Mewaldt, 1953; and doubtfully Eyster, 1954) and the deposition of fat (Farner, 1955, citing Farner, Mewaldt, and McGreal); however, Farner *(in litt.)* informs me that these findings referred to a difference in temperature of 20°C., and that later work with smaller and more normal changes in temperature showed no demonstrable effect.

Migratory restlessness in autumn was associated with cold in captive Song Thrushes *(Turdus ericetorum)* (Siivonen and Palmgren, 1936; Wagner, 1937), Robin *(Erithacus rubecula)* (Putzig, 1938a), and European Whitethroat *(Sylvia communis)* (Merkel, 1938), and though Weise (1956) concluded that temperature had no particular influence in the autumn, his graphs suggest that in both *Zonotrichia albicollis* and *Spizella arborea* most migratory restlessness occurred in cold spells.

Variations in the Effect of Temperature

While various authorities have thought temperature important, others have not. For the latter negative view, there are several different reasons. First, other weather factors are certainly important, and in some studies these may have had an overriding influence. Second, a change in temperature may usually coincide with a change in some more-conspicuous weather factor, notably wind direction, to which

the observer wrongly attributed the noted difference in migration. Third, in some studies temperature probably did not reach its critical value, as, for instance, for the Red-breasted Nuthatch *(Sitta canadensis)* in the early part of the autumn (Ball, 1947), and for spring emigrants from Norfolk in May (Lack, 1960). Further, the temperature that is critical may vary with the time of year, as probably for the spring return of the Song Sparrow *(Melospiza melodia)* (Nice, 1937) and the spring emigration from Norfolk (Lack, 1960). Such seasonal differences are presumably linked with seasonal differences in the internal state of the bird, and other apparent differences in the effect of temperature may also have been due to variations in the internal state.

Authors have also differed as to whether the response to temperature is immediate or gradual. In all hard-weather and reversed movements, the response is evidently immediate. In true autumn migration, likewise, a big passage may occur on the first day of cold, as often recorded, for instance, in northwestern Europe. But here, as already mentioned, the response may not be due simply to temperature, since the change to cold is normally accompanied by a favorable change in other weather factors, and, in addition, there has usually been a previous hold up during disturbed weather. Hence, detailed analysis of this case is at present difficult. In Norfolk in spring, on the other hand, emigration did not normally start on the first day of a change from cold to warm, even when the change was large, and the marked influence of temperature on the volume of emigration from here was an average one, associated with sustained spells of warm or cold weather (Lack, 1960). A similar conclusion was reached by Bergman (1941) for Finnish ducks, though various other workers in several countries have recorded extensive movements on the first day of a warm spell in spring.

Temperature likewise had an immediate influence on the migratory restlessness of a captive European Robin in both spring (Palmgren, 1937) and autumn (Putzig, 1938a), but though various reviewers have implied that the effect was also immediate in the Song Thrush *(Turdus ericetorum philomelos)* studied in autumn by Siivonen and Palmgren (1936), their published graph does not suggest to me a day-to-day correlation with temperature. In the European Whitethroat *(Sylvia communis)* (Merkel, 1938), in the White-crowned Sparrow *(Zonotrichia leucophrys)* (Farner, 1955), and in the three other American buntings studied by Weise (1956), the influence of temperature was, or appeared to be, cumulative and gradual. In a general discussion, Hinde (1951) postulated that temperature might influence migration in two ways, either directly initiating movement or gradually changing

the bird's internal state, and the evidence in this section suggests that both effects may occur.

WIND DIRECTION

As already mentioned, in both Europe and North America migrants tend to arrive in spring with warm, following winds and to leave in autumn with cold, following winds. But since the laboratory experiments on migratory restlessness show that both warmth in spring and cold in autumn are favorable to migration, the field evidence is quite inadequate to show that wind direction in itself has any influence. The observations in question need not be discussed further except for those of two American authors who definitely attributed the results in question to wind direction.

Devlin (1954) found a nocturnal migration in spring through Philadelphia on only two out of 32 nights with a northerly wind, but on 25 out of 30 nights with a southerly wind. Moreover, of the five nights of no migration with a southerly wind, four had heavy rain. This strongly suggests that following winds favor migration; but Devlin classified as "southerly" any wind blowing from between east-southeast and west-southwest, and these outside limits could hardly be classified as "following." Furthermore, he added that "southerly winds and mild weather go hand in hand." Hence, the observed effects could well have been due to temperature alone. Classifying wind directions in a similar way, Raynor (1956) found big spring arrivals of night migrants on 113 occasions with favorable winds as compared with 40 occasions with unfavorable winds; but of the latter, 19 occurred with a favorable wind higher up, seven with a favorable wind farther south, and two in a doubtful situation, leaving only 13 arrivals against the wind, in all of which the wind was light, usually 5–10 knots. As already discussed, Raynor's findings also might perhaps be explicable in terms of temperature.

Two other investigators discussing the spring migration in North America thought that wind direction was important: "whenever possible, migrating birds ride the wind" (McMillan, 1938); "most night-migrants travel by a system of pressure-pattern flying" (*i.e.*, downwind) (Lowery, 1951). But Macmillan provided no critical evidence, and I suggest that Lowery's maps for the directions of night migrants might be interpreted according to a different hypothesis, namely that the spring migration is stimulated by warmth and that, by coincidence, the northerly heading of the migrants in question is near to that of the wind direction during warm spells. Lowery's averaged tracks did not appear to be quite downwind, and might, I suggest, have been the resultant between the birds' normal headings and lateral displacement by the wind.

As regards the fall in eastern North America, Bagg *(in litt.)* has already been cited that a cold front may initiate migration even when the wind is from the southwest, demonstrating that it is not the wind direction but temperature that is important.

As regards Europe, the big diurnal movements in Sweden in autumn, all of which are associated with a drop in temperature, occur with winds varying between north and west (Svärdson, 1953), while big movements on the east side

of the North Sea in autumn occur with a drop in temperature and winds varying between northeast and southeast (Clarke, 1912). Since in both areas the wind in question is anywhere between a directly following one and one at right angles to the heading of the birds, it is most reasonable to assume that the movements in question are stimulated by the drop in temperature and not by the direction of the wind. In this connection, a revealing incident was recorded by Putzig (1938a): a big October passage of crows *(Corvus spp.)* through the Kurische Nehrung in East Prussia was attributed by the local bird catchers to the southeasterly wind, but on the same day migratory restlessness started in a caged Robin, which was screened from the wind but exposed to the drop in temperature. Again, Ritchie (1940) found that southerly departures of Waxwings from Norway took place with winds varying between northeast (only once), east (6), southeast (2), and south-southeast (4), *i.e.*, the wind was usually at right angles and sometimes almost opposed. Further, Ritchie's data do not exclude the possibility of Waxwings also having taken off with westerly winds, since if they did so, they would have been drifted to the Continent and so would have escaped record in Britain. Hinde (1951) likewise considered that wind direction did not influence the return of limicoline species and terns to England in spring.

Williamson (1953, 1958) claimed that Wheatears *(Oenanthe oenanthe leucorhoa)* from Greenland and the migratory passerine species from Iceland reach Britain in autumn primarily with westerly or northwesterly following winds. "The cases examined do suggest, very pointedly, that the migration out of the northwest is simply a down-wind drift" (1953: 92). "There is thus abundant evidence in the meteorological correlation of Wheatear records at sea . . . and through Fair Isle, of extended cyclonic journeys" (1958: 219). But there is, in my view, no critical evidence as yet to support this view. In particular, the occurrence of these species on Fair Isle in autumn with westerly but not easterly winds may be merely because it is only with westerly winds that they are drifted so far off course to the east. I (1959b) have discussed this case further elsewhere, with a possible misunderstanding of it. Although I regard it as quite unproved, it needs further study, if only because the passage of the Greenland Wheatear to western Europe is, so far as yet known, the longest sea crossing regularly made by a passerine migrant.

My own observations by radar in Norfolk are as yet inconclusive for the autumn, for though most westward movements from Holland take place with easterly winds, such winds usually coincide with all the other weather factors favoring migration at this season, as already discussed. The westward movements of Lapwings from Holland to England in June and July also occur primarily with following easterly winds (Lack, 1959a), but the figures are as yet too few to test whether or not other weather factors might be involved. For the eastward emigration from Norfolk in spring, however, I (1960) have sufficient data to show conclusively that wind direction as such had no significant influence on the volume of emigration. The mean volume of spring emigration was not the same for all wind directions, being greatest for winds ranging between westerly (following) through southerly (at right angles) to southeasterly (partly opposed), and least for winds ranging through easterly (opposed) through northerly (at right angles) to northwesterly (partly following). But this was presumably because northerly winds were usually cold and southerly winds warm; following winds as such were not favored.

One important series of observations appears to be in contrast to these other findings, since the Dutch investigators reviewed by Van Dobben (1953) showed that in autumn Chaffinches migrate across Holland higher with following easterly winds than with opposed southwesterly winds, and that they tend to put out to sea with easterly winds but to turn along the coast with southwesterly winds. Less-detailed observations suggest that the same holds for the Starling. These findings have been widely quoted as showing that wind direction as such has an important influence on the volume of seaward emigration. However, Deelder (1949: 79) and Vleugel (1951) pointed out that following easterly winds are associated with other weather factors favoring migration, while opposed southwesterly winds are associated with other factors unfavorable to migration. Van Dobben (1953) stated that these other factors have some influence; further, Vleugel (1951) reported that seaward departures may occur with westerly winds. The problem is therefore essentially the same as that for other autumn movements in northwestern Europe, including nocturnal movements, which, as already mentioned, are favored by cold, anticyclonic weather with easterly winds and not by warm, disturbed weather with westerly winds. Further analysis is therefore needed as to the particular weather factors inducing Chaffinches to fly higher with easterly than southwesterly winds, and until this has been done, judgment on this case should be suspended.

In summary, with the possible exception of the autumn migration of Chaffinches in Holland, the available evidence suggests that wind direction as such does not influence the volume of migration, and that, while migration is more common with following than opposed winds, this is normally due to other associated weather factors. This conclusion was unexpected, for one might have supposed that it would be advantageous for migrants engaged on a sea crossing to wait, if possible, for a following wind; this they apparently do not do. They tend, however, to migrate with light winds, and under these conditions the direction of the wind may not be of appreciable importance.

As already mentioned, many earlier observers claimed that more diurnal migration occurs with opposed than following winds, the latest instance being Vleugel (1954), who reported that, with winds of moderate strength, migration was seven times as dense with head winds as with tail winds. The usual reason, of course, is merely that migrants fly lower with head winds, so that more of the migration is visible. A second reason, applicable locally, is that coasting migrants normally turn into the wind, which means that wind direction influences the direction but not necessarily the volume of migration (though wind direction may influence the volume passing within visual range of a particular place). Coasting birds normally turn into the wind both prior to seaward departure and after arrival from the sea (references and discussion in Lack, 1959b).

Influence of Time of Day

The volume of migration varies markedly with the time of day. The peak of nocturnal migration normally comes soon after dark and before midnight, as shown by Palmgren (1949) for migratory restlessness, Lowery (1951) by moon watching, and Sutter (1957a,b) by radar; the actual hour probably depends chiefly on the hour of sunset, and is much earlier at seasons when the day is shorter (Lack, 1959a). Di-

urnal movements of small, passerine species are usually heaviest about an hour after sunrise, with a steep decline later in the morning and hardly any movement in the afternoon (Sutter, 1957a,b; Lack, 1959a, 1960). However, most large, diurnal migrants, such as raptors and storks, that use thermals, tend to travel in the middle hours of the day, when thermals are strongest. The same possibly holds for hirundines and swifts, though the point does not seem to have been investigated in detail for the latter birds.

Times of day vary somewhat with the weather. In favorable weather in Norfolk in spring, for instance, emigration occasionally continued throughout the 24 hours, while typical night migrants not infrequently set off an hour before dark and occasionally in midafternoon. On the other hand, when rain fell at the usual time of the nocturnal peak, but cleared later, a big, seaward emigration occasionally started after midnight, though this might have started from farther inland (Lack, 1960).

THE INTERNAL STATE

As pointed out long ago by Cooke (1915), the internal state of the bird is primary, and the weather secondary, in initiating migration. "It must," wrote Cooke, "be a force from within, a physiological change . . . that impels them to spread their wings for their long flight." In this connection, he specifically cited the spring departure of northern migrants wintering in the tropics. The same point, often illustrated by the same example, has been emphasized by various later writers.

The subsidiary influence of the weather in initiating migration may be briefly illustrated by five instances. First, as just mentioned, species wintering in equatorial regions leave at the appropriate season in spring without any obvious change in the local weather, as recently shown by Curry-Lindahl (1958) for Yellow Wagtails wintering in Africa. Second, in England, types of weather that, in spring, would be associated with heavy migration may occur in midsummer without any migration. Third, in Scandinavia in autumn, after a hold up due to unsettled weather, the onset of weather suitable for migration may result in an "avalanche," the number of migrating birds being much greater than in good weather at other times (Svärdson, 1953). Fourth, after a long hold up due to cold weather in Norfolk in the spring of 1958, many birds eventually emigrated in cold weather during which, in ordinary years, little or no migration takes place (Lack, 1960). Finally, in addition to such broad effects, continuous watch for migration, at least by radar, shows that it is not normally a question of either a big movement or none; there are many days with a moderate or small movement

on which, evidently, some individuals migrate while others do not, though the weather is the same for all.

Hence the influence of the weather cannot be properly assessed without considering the internal state of the birds. In the latter connection, the term "migratory urge" is unsatisfactory, as it is vague, carries subjective associations, and has been used in different senses by different workers. Like "drive," it has sometimes been employed to distinguish the internal from the environmental factors influencing behavior, but it has also been used for the actual motivation of behavior as a result of external and internal factors combined (Hinde, 1959: 585). Since it is valuable to have a term for the internal, physiological condition of a migrant prior to migration, I propose "migratory state," which is intended as equivalent to the German "Zugdisposition." I rejected "migratory disposition," as "disposition" carries subjective associations and, in English at least, seems too similar to "migratory mood," which is a translation of the German "Zugstimmung," a concept usually treated as distinct from "Zugdisposition."

The migratory state is recognizable, apart from actual migratory behavior, by the presence of large deposits of peritoneal and subcutaneous fat. It is also characterized by a different hormone complex from the nonmigratory condition, though details are not known. Nor is it known whether the hormone complex differs in spring and autumn, as might well be the case. Hormonal changes evidently precede the deposition of migratory fat, which once started proceeds rapidly, as it also does in a transient with depleted fat stores.

Internal Factors Influencing the Migratory Condition

Laboratory experiments on the hormones and other internal factors influencing migratory restlessness were initiated in Finland and Germany before the war, and have been carried out after the war, especially in Germany and the United States. This work has been reviewed so comprehensively by Farner (1955) that it need be mentioned only briefly here. The original theory behind the pioneer work of Rowan (1926) was that, in spring, hormones produced by the developing sex organs stimulate migration. But this view has now been extended to the wider one that both the migratory state and the maturation of the gonads are under the control of the anterior pituitary. Indeed, Wagner (1957) and Wagner and Thomas (1957) recently claimed that some of the gonadal hormones actually inhibit migratory restlessness in spring. If confirmed, this would explain the point mentioned earlier: that migratory restlessness continues throughout the summer in captive birds prevented from breeding, but ceases in those that breed.

In order to deposit migratory fat, a bird must have a favorable energy balance, which in spring might well be helped by the warmer and longer days. But such a favorable energy balance is merely a prerequisite, and does not mean, as tentatively suggested by Kendeigh (1949) and cited by Farner (1955), that "spring migration . . . may

conceivably be induced by the change in the energy balance." As Kendeigh pointed out, resident species also have a favorable energy balance in spring yet do not migrate, and the critical question is what factors direct the migrant's, but not the resident's, energies into a special type of fat deposition and eventual migration at this season. It is now becoming accepted that fat reserves are an important special adaptation for long-distance migration. George and Jyoti (1955a,b) showed that the energy for long flights comes primarily from this source. Wolfson (cited by Bagg, 1955) and Odum (1958a,b) concluded that fat deposits may set the limit to the length of the migratory flight, while Williamson (1952, 1955) showed that passerine migrants drifted far off course to Fair Isle have commonly lost all their fat, which they normally replace before again setting out (see also discussion and references in Lack, 1959b). The physiological aspects of fat deposition have been reviewed by Farner (1955), Wolfson (1942, 1945, 1954a,b), and Odum (1949, 1958a,b) (see also Odum and Connell, 1956; Odum and Perkins, 1951; and Norris *et al.*, 1957), and need not be treated further here, except for a point stressed by Farner *(in litt.)* that it is not merely the possession of fat stores, but their rapid replenishment after depletion, that characterizes the migratory state.

Whereas in spring many birds assume the migratory state as the days lengthen and grow warmer, similar fat deposition takes place prior to the autumn migration at a time when the days are growing shorter and colder. In autumn, moreover, the anterior pituitary is in its refractory condition, at least so far as the gonadotrophins are concerned, so it cannot be playing the same role as in spring. It therefore seems better to think of the migratory state as initiated and maintained at both seasons by a combination of external and hormonal factors that are in essence timing regulators; the factors used for this timing could well be different at the two seasons. Recent work in both Germany and the United States (Farner, 1955; Wagner, 1956, 1957a,b; Merkel, 1956, 1958) has thrown valuable light on the hormones involved in spring, but little is yet known about the autumn.

INFLUENCE OF BREEDING CYCLE ON AUTUMN MIGRATION

A further factor that might perhaps influence the timing of the autumn migration is the completion of breeding. However, in nearly all migrant passerine species in north-temperature regions, there is an interval of several weeks, and in some species of a few months, between the raising of the young and the start of migration. This interval is shorter in small, insectivorous forms, such as warblers, flycatchers, and chats,

which depart chiefly in September, and longer in larger species and seed eaters, such as many finches, thrushes, Starlings, and crows, which migrate chiefly in October. The interval is partly filled by the molt, but at least in those species that leave in October, there seems ample further time, and one gets the strong impression that in these species the end of breeding and the end of the molt are not critical in the timing of the autumn departure. However, since little is yet known about molting requirements, this point should be studied further. Hirundines, which differ in molting in their winter quarters, also seem to stay in their summer haunts for several weeks after breeding, though a few late-breeding House Martins *(Delichon urbica)* continue breeding until almost the day of departure.

In marked contrast to these passerine migrants are Swifts *(Apus apus)*, in which each pair leaves within a few days of raising its brood (Lack, 1958a). In this species, the date of departure is clearly determined primarily by the completion of breeding, though in unfavorable climates like that of England, the parents usually stay for a few days after their young, presumably to put on migratory fat. Since the chief factor influencing the date of departure is the end of breeding, and the chief factor influencing the latter is the date when breeding starts, which itself is greatly influenced by temperature, the mean date of departure of Swifts in autumn depends on the weather in the previous May. The weather during the summer has a subsidiary influence, since in bad weather when food is scarce nestling periods are prolonged, while bad weather around the time that the young leave delays the departure of the parents by a few days, presumably because it then takes them longer than usual to put on migratory fat. In 1959, which was the finest summer experienced in England for many years, I found that Swifts also left markedly earlier than in any previous year of my 13-year study, most having gone by the beginning of August. This was because in 1959 they started breeding earlier than usual, had short nestling periods, and a short interval between the departure of young and adults. Yet in 1959, feeding conditions remained unusually favorable for Swifts throughout August. Swifts presumably leave immediately after breeding because, at this time of the year, conditions affecting their survival are more favorable for them farther south than in their breeding haunts.

A similar principle to that found in Swifts holds for arctic waders, which evidently leave just after breeding, so that the time of the autumn passage depends on the time of the preceding spring migration, and hence on the spring weather (Nisbet, 1957b). Presumably, other species of the far north leave immediately after breeding, but the subject requires further study.

In conclusion, the evidence in this section suggests that the termination of breeding or of the molt has an important influence on the date of departure in some species but not in many others.

EXTERNAL FACTORS INFLUENCING THE MIGRATORY STATE

While the weather has an immediate influence on the amount of migration in birds already in their migratory state, it may also influence the migratory state itself. In particular, the instances cited earlier in which temperature was found to have a gradual, rather than an immediate, influence on the volume of migration suggest that temperature may influence the migratory state. Hence, warmth may act as a positive timing factor in spring, and cold as a positive timing factor in autumn.

Another factor influencing migratory restlessness in captive birds is food (Wagner, 1937, 1956, 1957a), but this might mean no more than that a bird must be well nourished in order to deposit migratory fat. As already mentioned, underweight migrants drifted to Fair Isle do not normally leave again until they have replenished their fat.

Of greater interest is the fact that, in winter and early spring, an experimentally increased day length resulted in premature migration in the Slate-colored Junco *(Junco hyemalis)* (Rowan, 1926, 1929), Oregon Junco *(J. oreganus)* (Wolfson, 1942), and American Crow *(Corvus brachyrhynchos)* (Rowan, 1930, 1932), also in premature migratory restlessness in the European Robin (Putzig, 1937, 1958b; Schildmacher, 1937, 1938b), and in premature deposition of migratory fat in Oregon and Slate-colored Juncos (Wolfson, 1942, 1952), Golden-crowned Sparrow *(Z. coronata)* (Miller, 1948), White-crowned Sparrow *(Z. leucophrys)* (King and Farner, 1956), White-throated Sparrow *(Z. albicollis)* (Odum and Major, 1956), Chaffinch (de Bont, 1947; Koch and de Bont, 1952), and Brambling *(F. montifringilla)* (Schildmacher and Steubing, 1952). Although a longer day gives more time for feeding, the important factor is evidently the longer day itself, which presumably acts as a timing regulator for various physiological responses, including hormone secretions.

Different species wintering in the same area, and hence subject to the same light ration, may nevertheless start their return migration at very different dates, which may be weeks and sometimes months apart. Indeed such differences are even found in different breeding populations of the same species wintering in the same area, as shown for White-crowned Sparrows in California (Blanchard, 1941), Starlings in England (Bullough, 1942), and Yellow Wagtails in tropical Africa (Curry-Lindahl, 1958). Such differences are ultimately related to differences in the time at which breeding becomes possible in the breeding areas of the populations concerned, and they have presumably resulted through the populations concerned evolving differences in their threshold of response to day length and other external factors.

While increasing day length seems to be used as a timing regulator by many northern passerine species in spring, it cannot be used universally. In particular, the many species wintering in almost uniform conditions of day length in the

tropics presumably depend for the initiation of their spring migration on different external factors, or on internal, rhythmical factors, the latter perhaps linked with external stimuli at some time when the birds are on their breeding grounds (Curry-Lindahl, 1958; Marshall and Williams, 1959). Further, almost all migrants in autumn, also transequatorial migrants in the northern spring, set out when day length is decreasing. The possibility that decreasing day length might be used as a timing regulator in autumn has not been investigated.

The reason that both day length and temperature may be valuable timing factors for the spring migration of northern birds was made clear by Hinde (1951), citing the close parallel with the work on northern breeding seasons. Such birds need some factor to bring them into their migratory state at about the same date every year, and hence a factor that is effectively constant from year to year. An internal regulator might do this, but as stressed in a review by Thomson (1950), it is probably more reliable to have an external factor where this is available. In north-temperate regions, day length provides changes that are both large and constant from year to year. However, since in northern latitudes the weather varies from year to year, between cold, late springs and warm, early springs, it is clearly advantageous for a bird to be able to modify its response to the constant influence of day length by a response to the variable influence of temperature, if it is to arrive on its breeding grounds at what is ecologically the appropriate time.

RESPONSIVENESS TO WEATHER FACTORS

A bird in its migratory state normally sets out in favorable but not in unfavorable weather. To "explain" this (though it is at best a description, not an explanation), some workers have stated that fine weather, or a particular weather factor, "stimulates" migration. Other workers have stated that bad weather, or a particular weather factor, "inhibits" or "deters" migration. Yet others have made statements of either type loosely or interchangeably. Nisbet (1957a) made a distinction between the two concepts, and after stressing that the chief factor determining migration is the bird's internal drive, concluded (p. 232) that "the external factors are therefore significant as inhibiting rather than stimulating migration." In this connection, he had particularly in mind the effects of wind and rain, and later (on p. 232) he wrote of "falling temperature providing a direct stimulus" (in autumn).

At first sight, Nisbet's distinction seems reasonable, for rain makes flying difficult, strong winds may produce drift, and fully overcast conditions impede navigation, so natural selection has presumably operated against travel in such conditions. Cold, on the other hand, carries no

such obvious disadvantage, and when it is followed almost immediately by a large, autumnal departure, it certainly appears to be acting as a positive stimulus. I suggest, nevertheless, that the distinction between "stimulus" and "deterrent" in this context may be unreal. All that is observed is that the volume of migration increases as the amount of wind, cloud, and rain decreases, and as temperature rises in spring and falls in autumn. In such a quantitative relationship, it seems irrelevant to dispute whether the scale should be read in one direction (positive stimulus) or the other (negative deterrent).

Moreover, the "explanatory" value of such terms as "stimulus" and "deterrent" may be questioned, and seems largely illusory, at least without a profound analysis of the causal links in migratory behavior. Further, the terms carry inappropriate associations with subjective human states of mind, and also with energy or power. It is said, for instance, that "sudden cold is a *powerful* stimulus to autumn migration," but where the implied power might reside seems speculative. I therefore suggest that, in the present state of knowledge of migratory behavior, these terms should be omitted, and that this can be done without any loss in precision or comprehension, and with a gain in clarity. I suggest that the relationship of each weather factor to the volume of migration should be expressed quantitatively, in terms of less and more, or with actual figures where these are available, while if a vaguer statement is needed, it can be said that certain types of weather are "associated with" or "favorable to" migration, while their opposites are "unfavorable" to migration.

Certain types of weather are "favorable," of course, only when birds are in their migratory state. This is probably not an all-or-none response. It need not be supposed that migration occurs simply when the migratory state has been fully assumed and each weather factor has reached a particular threshold value. The relationship is almost certainly more complicated, since "if the internal changes are well advanced, then migration may occur even under apparently unfavorable conditions: but if the . . . drive is low, spring migration will occur only with particularly favorable weather" (Hinde, 1951: 336). Both of Hinde's postulates are presumptively illustrated by the spring emigration from Norfolk, since as already mentioned, in April 1958, after a long hold up ("internal changes well advanced"), big movements occurred in unusually cold weather, while at the start of the season in February ("drive low"), migration occurred only in very warm weather (Lack, 1960). Hinde also emphasized a further complication: that the influence of each weather factor probably varies with the state of the others. "The effects of the various external weather factors are

probably additive, as in other instinctive activities (Law of Heterogeneous Summation)." While the latter principle was originally postulated for social sign-stimuli, it doubtless holds for the external factors influencing migration. For instance, one might expect migration to occur on a clear night with a moderately strong wind, or on a windless night with moderate cloud, but not, perhaps, on a moderately windy and moderately cloudy night.

The foregoing discussion applies to true migration. Hard-weather movements, as already mentioned, come in a partly, if not completely, different category, since they apparently occur as an immediate response at any time during the winter, or even after the birds have started, or completed, their spring migration. Perhaps, therefore, they occur irrespective of the internal condition of the bird, but the latter should be investigated. It may be repeated that many of the species concerned also have true autumnal migrations, which may be in the same direction as hard-weather movements, and may be preceded by the same general type of weather situation, so that the two types of movement perhaps intergrade.

MIGRATORY READINESS

Groebbels (1928) introduced from his earlier analysis of bird song the two terms "Zugdisposition" and "Zugstimmung," the first being essentially physiological and correlated with the internal secretions, and "Zugstimmung" (literally "migratory mood") being essentially psychological and correlated with the sense organs. The two terms have been used vaguely and with rather different meanings by some later investigators, and Verwey (1949) argued that two were unnecessary. However, if "Zugdisposition," like "migratory state," is restricted to the internal physiological changes preceding migration, then "Zugstimmung" might be useful for referring to the state of a migrant when the combined influence of internal and external factors has brought it into a condition of immediate readiness for migration. This is, or is close to, Groebbels' original usage, and brings it into line with one of the meanings attached to "Stimmung" in later work on animal behavior in general, where it has been particularly used in considering short-term changes in the readiness to respond to external factors.

As already mentioned, this second meaning has also been given to, or implied in, the term "migratory urge." But apart from the latter having also been used for the concept of "Zugdisposition," it has several disadvantages. First, it seems hard to measure it except by the occurrence of migration (or migratory restlessness). Hence, it might be a tautology to say, for instance, that "there is more migration (or migratory

restlessness) when the migratory urge is stronger." Further, the term "urge" is vague, carries subjective human associations, and provokes the question "who is urging what?" Substitution of the term "migratory drive" might seem more objective, but the analogy that it implies is open to the same objection, since both "driver" and "driven" are the bird itself. Howard (1935) warned that such terms open the way to dualistic interpretation and mythical entities (cf. Lack, 1943), but this warning seems to have been unheeded or glossed over by nearly all later writers on animal behavior, an important exception being Hinde (1959b).

For these reasons, I at first supposed that the concept of "Zugstimmung" was unnecessary. However, I once in France observed Blue Tits *(Parus caeruleus)* migrating along the coast until they came to a bay; flocks then set off over the water, but single migrants normally hesitated and alighted in the bushes, rising into the air again when a further migrating party came in sight, joining them, and then crossing successfully (Lack and Lack, 1953). One might therefore say that the "Zugstimmung" of the single birds was counteracted by the appearance of (or fear of) open water, and supplemented by the presence of a flock (or, perhaps less probably, that the strength or level of the "Zugstimmung" was lowered by the sight of water and raised by the sight of a migrating flock). Again, limicoline species interrupting their migration for a few hours or days at the Cambridge Sewage Farm showed characteristic behavior when setting off again, running rapidly and calling, raising the wings, taking short flights, rising fairly high and again descending, until finally setting out, after which a few individuals sometimes detached themselves from the flock, returned, and did not leave that day (Lack, 1930). One might perhaps say that the "Zugstimmung" of these latter individuals was not strong enough to sustain their migration, though it is also possible that the movements of their fellows preparatory to flight caused them to fly up with them, and that they ceased to fly when the migratory, or lengthy, character of the flight became obvious. Again, in an incident already quoted, when a huge flock of migrant Starlings *(Sturnus vulgaris)* left the Cornish coast in the direction of Ireland, some turned back after meeting drizzle, perhaps those whose "Zugstimmung" was weaker, though it is also possible that these individuals had met denser drizzle than the rest. Finally, the peak of passerine night migration usually comes about an hour after dark, and the peak of passerine diurnal migration an hour after sunrise, and this diurnal periodicity is presumably due to variations not in the migratory state ("Zugdisposition"), but in the "Zugstimmung" (or in factors that counteract or supplement the "Zugstimmung").

Hence, the concept of "Zugstimmung" might be useful for analyzing certain types of difference in migratory behavior, and in the above examples, it can be given a meaning distinct from both "Zugdisposition" and the act of migration itself. The best translation for "Zugstimmung" may not be "migratory mood," with its subjective associations, but either "migratory readiness," which indicates a psychological state of the bird, or "migratory tendency," which is less satisfactory as

indicating a psychological state, but more satisfactory if one has to talk of increasing or decreasing it. As this paper is not primarily concerned with motivation, I leave the choice to others. I would plead, however, that terms of this type should be used only of necessity, that they are not usually necessary at the comparatively simple level attained by most, if not all, field studies of migration, and that their omission usually means a gain in clarity.

The Selective Value of Environmental Influences

While the nature of the migrant's responsiveness to weather factors is still obscure, the reason that particular responses have been evolved is in most cases clear. Summarizing what was said earlier, it is disadvantageous to migrate in rain, which impedes flight, in strong wind, which causes drift, and in fully overcast conditions, which impede navigation. Correspondingly, it is advantageous to migrate in fine, calm, and clear weather. Further, it is advantageous that a migrant's response to weather factors of this type should be immediate. On the other hand, the response of many northern migrants to day length is long term, since changes in day length act as an internal timing regulator, bringing the birds into their migratory state at that date in spring, which is, on average, that best adapted to the ecological conditions. But since in northern regions the time of appearance of suitable ecological conditions varies somewhat from year to year, primarily due to variations in temperature, it is advantageous for the birds concerned to have evolved a response to temperature, modifying the effect of day length in such a way that, in spring, cold retards and warmth accelerates the assumption of the migratory state.

It also seems probable, though the evidence is not certain, that some northern species of migrants have evolved an immediate response to temperature. An immediate response to warmth in spring might be advantageous either if, in the species concerned, warmth farther south is an indication that the breeding grounds have become suitable for occupation, or if warmth at this season is associated with conditions generally favorable for travel (which it might be on continents, though not around the North Sea). Similarly, an immediate response to cold in autumn might be advantageous either if the onset of cold immediately precedes the time when the breeding grounds become unsuitable for survival, or because cold is normally associated in autumn with the onset of anticyclonic weather favorable for travel. With respect to the autumn, the association of cold with favorable conditions for travel would seem the more likely alternative, were

it not that the immediate response of various species to hard weather in winter is clearly advantageous on account, not of travel conditions, but of impending food shortage. The species concerned in hard-weather movements in northern Europe are primarily those that feed on fields, marshes, or fresh waters, habitats that quickly become frozen or covered by snow in hard weather. In either case, the migrants have presumably evolved their response to cold because of its association with some other factor, and cold acts in autumn as an immediate signal, either of conditions favorable for travel or of impending food shortage, and perhaps of both.

SUMMARY

1. This review is primarily concerned with passerine migrants in north-temperate regions.

2. The numbers of diurnal migrants seen moving by day, and the numbers of night migrants on the ground, constitute a variable proportion of the migration passing overhead. The most useful techniques for analyzing the influence of weather on migration have been migratory restlessness in the laboratory and radar in the field.

3. The rôle of climate in the evolution of migratory seasons seems primarily connected with ecological, not travelling, conditions.

4. Migration is unaffected by the general weather situation as such or by barometric pressure, while the available evidence suggests that it is also unaffected by stable air conditions, or by wind direction as such.

5. There is more migration in fine weather than in rain, more with clear than cloudy skies, and more with light than strong winds, these factors, which influence travelling conditions, having an immediate effect.

6. There is more migration in spring with warmth and in autumn with cold. Probably, the response to temperature is sometimes immediate. But at other times, at least in spring, it is certainly gradual or long term, temperature influencing the migratory state *(Zugdisposition)*.

7. The migratory state, including fat deposition, is also influenced by day length and by internal factors. Both day length and temperature may be regarded as timing regulators.

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THREE NEW SUBSPECIES OF BIRDS FROM WESTERN NORTH AMERICA

THOMAS D. BURLEIGH

In connection with a proposed report on the distribution and abundance of the birds of Idaho, collections made in the northwestern United States were examined critically to determine the geographic variation in those species breeding in that part of the country. Three were found to represent distinct and undescribed races, with characters that readily separated them from other breeding populations. These are as follows:

Actitis macularia rava new subspecies.

Characters. Breeding adults similar to *Actitis macularia macularia* but upperparts dark gray rather than grayish brown and with but a faint trace of the metallic gloss characteristic of the nominate race; underparts less heavily spotted and the spotting less intensely black; winter adults and young of the year equally distinct, the upperparts being brownish gray in contrast to the dark brown of *macularia;* no appreciable size difference.

Measurements. Adult male (6 breeding specimens from Idaho): wing, 96–106 (103.1) mm.; tail, 42–52 (47.2); exposed culmen, 21.5–23.5 (22.4). Adult female (4 breeding specimens from Idaho): wing, 97.5–103.5 (101.5); tail, 49–53.5 (51.5); exposed culmen, 22.5–26.5 (25).

Type. Adult male, No. 465960, United States National Museum (Fish and Wildlife Service collection), Lewiston, Nez Perce County, Idaho, 21 June 1958; Thomas D. Burleigh, original number 17651.

Distribution. Breeds wherever suitable habitat occurs from northwestern Alaska, Yukon and western Mackenzie south through British Columbia, Washington, Oregon, and Idaho. Winters in the West Indies (Puerto Rico) and Central America (Honduras) southward to Venezuela and Peru. In migration eastward in the United States to Louisiana and South Carolina.

Remarks. Extensive mountain ranges in the western United States have been shown to be effective barriers in the distribution of birdlife in this part of the country, a situation that apparently exists in the distribution of the northwestern race of *Actitis macularia.* Although occurring in southern Oregon, the Siskiyou Mountains of northern California would appear to limit the occurrence of *rava* farther south, the breeding birds of California being typical of *macularia.*[1] In the same way the Continental Divide marks the eastern limits of *rava* in

[1] I am indebted to Dr. Alden H. Miller and the Museum of Vertebrate Zoology for the loan of breeding specimens of *Actitis macularia* from California.

the northwestern United States, breeding specimens from Montana and Wyoming that were examined representing the nominate race. A female taken at Glasgow, Montana, on 7 June 1919, was found to be *rava* but was probably a transient from farther west, for 12 other specimens taken during June in western Montana east of the Continental Divide were referable to *macularia.* The western subspecies apparently crosses the Continental Divide in Canada, and northeastern Alberta and eastern Mackenzie would appear to represent an area of intergradation between the two races of *Actitis macularia.* Specimens taken at Fort McMurray, Alberta (a female, 7 May 1920), and at Great Slave Lake, Mackenzie (a female, 12 June and a male, 15 June 1908), are intermediate in their characters but closer to *macularia.* The upperparts are noticeably gray but browner than in *rava,* and have the metallic gloss lacking in the western race. A male in immature plumage taken at Big Salmon River, British Columbia, on 17 August 1914, is clearly *macularia* and is probably an early-fall transient from farther north.

Specimens of Actitis macularia rava examined. Total number, 80, from the following localities: *Idaho*—Boundary County, Bonner's Ferry, 22 June 1957, ♀; Bonner County, Sandpoint, 19 August 1958, ♀ im.; Shoshone County, Clarkia, 5 July 1948, ♂; Clearwater County, Headquarters, 17 May 1953, ♀; Latah County, Potlatch, 14 May 1950, ♀; 30 July 1950, ♂ im.; 18 August 1951, ♀ im.; 24 August 1951, ♂ im.; 8 September 1953, ♂ im.; 14 May 1954, ♂; 25 July 1954, ♂; 12 May 1955, ♀; 1 July 1955, ♂; 4 July 1956, ♂; 15 July 1956, ♂ im.; 5 May 1957, ♀; 7 October 1957, ♀ im.; Polouse River, 11 June 1947, ♀; Moscow, 15 May 1949, ♂; 5 May 1951, ♀; 10 September 1952, ♀ im.; 17 July 1954, ♂; Nez Perce County, Lewiston, 2 August 1949, ♂ im.; 8 August 1949, ♂ im.; 13 August 1949, ♂ im.; 19 August 1949, ♂ im.; 1 September 1951, ♂ im.; 8 July 1953, ♀; 28 September 1953, ♂ im.; 4 November 1953, ♂ im.; 24 July 1954, ♂ im.; 4 August 1955, ♂; 21 June 1958, ♂; Adams County, New Meadows, 23 July 1958, ♂; Washington County, Weiser, 13 June 1913, ♂; Owyhee County, Silver City, 4 June 1910, ♀; Power County, American Falls, 1 June 1911, ♂; Oneida County, Juniper, 29 May 1916, ♀. *Washington*—Okanogan County, Pasayten River, 25 August 1920, im.; Clallam County, Elwha River, 18 July 1921, ♂; Spokane County, Spokane, 21 July 1955, ♂; Asotin County, Clarkston, 22 July 1956, ♀. *Oregon*—Ft. Klamath, 10 September 1882, ♂ im.; Bend, 30 July 1914, ♂; Pendleton, 16 July 1955, ♂. *Montana*—Glasgow, 7 June 1919, ♀. *Alaska*—Gustavus Point, 10 June 1899, ♂; Admirality Island, 26 September 1903, ♂ im.; Aniak, 11 August 1912, ♀; Bettles, Koyukuk River, 4 July

1950, ♀; Summit, 6 June 1952, ♀. *Yukon*—Old Crow Village, 8 June 1957, ♂; 13 June 1957, ♂ ♀. *Mackenzie*—Hay River, Great Slave Lake, 30 May 1908, ♂; Aklavik (near mouth of Mackenzie River), 13 June 1958, ♂. *British Columbia*—Head of Moose River, 15 July 1911, ♀. *Mexico*—Sonora, Hermosillo, 30 April 1892, ♂; Baja California, Gardner's Laguna, Salton River, 20 April 1894, ♂ and 23 April 1894, ♀; Concepcion Bay, 8 April 1911, sex (?); Pichilinque Island, 19 April 1911, ♀. *Guatemala*—Puerto Barrios, 7 April 1905, ♀; Peten:Remate, 15 April 1923, 2 ♀ ♀ (1 in almost completed breeding plumage, the other in full winter plumage). *Honduras*—Chamelicon, 3 January 1891, ♀. *Panama*—Rio Indio, 8 February 1911, ♀; Lion Hill (Canal Zone), 1 May 1911, ♀; Miraflores, 13 May 1911, ♂; Porto Bello, 23 May 1911, ♂; San Jose Island, Archipielago de las Perlas, 6 April 1944, ♀; Jaque, 25 March 1946, ♂; Mandinga, 31 January 1957, ♂. *Venezuela*—Cubata, 21 April 1903, ♂. *Peru*—Calca, 25 April 1917, ♂. *Puerto Rico*—Rio Piedras, 22 December 1911, ♂ im.; Culebra Island, 9 April 1912, ♀. *British West Indies*—St. Vincent, Vermont, 12 March 1937, ♀; Mayreau, 16 April 1937, ♀; Montserrat, spring of 1938, sex (?). *Louisiana*—New Orleans, 21 May 1935, ♀. *Texas*—Pecos River, 4 August 1902, ♂ im.; Cameron County, 8 May 1931, ♂. *South Carolina*—Porcher's Bluff, Christchurch Parish, 24 April 1911, ♀; 3 May 1911, ♂.

Sitta canadensis clariterga new subspecies.

Characters. Similar to *Sitta canadensis canadensis* but upperparts lighter and more bluish and lacking to a large extent the grayish wash characteristic of the nominate race. There are no appreciable size differences.

Measurements. Adult male (9 breeding birds): wing, 67–70 mm. (average 67.8); tail, 36–39.5 (36.6); exposed culmen, 11.5–13 (11.1). Adult female (4 breeding birds): wing, 65–68.5 (67.1); tail, 36–37 (36.6); exposed culmen, 11–11.5 (11.1).

Type. Adult male, No. 419620, United States National Museum (Fish and Wildlife Service collection), Headquarters, Clearwater County, Idaho, 15 June 1951; Thomas D. Burleigh, original number 13910.

Distribution. Breeds in the Canadian Zone from southeastern Alaska, British Columbia, and southern Alberta, south to southern California and southern Arizona. Winters largely within its breeding range, although unrecorded during the winter months in Alaska, and occurring irregularly then at the higher altitudes. Wanders extensively during occasional winters, but its movements then are erratic and unpredictable.

Remarks. *Sitta canadensis* was originally described by Linnaeus (Syst. Nat., ed. 12, Vol. 1, 1766, p. 177), with the type locality, if such it could be called, as "Canada." There is little question but that his description was based on *Sitta canadensis* of Brisson, whom he cites, and who, as in similar instances, used a specimen from the Museum of M. de Reaumur, taken in the general vicinity of the city of Quebec. This limits the type locality of the nominate race to Quebec, and since there seem to be no available names for the western population, the above name *clariterga* is applicable for this distinct subspecies.

It is in fresh plumage that the characters of this race are most evident. Breeding birds taken during the summer months are invariably rather worn and appear darker than fall or winter specimens. However, there is no difficulty in separating them from individuals in equally worn plumage from the eastern part of the country. A male taken by A. H. Howell (field number 2275) on Mt. Mitchell, North Carolina, on 3 June 1930, is distinct from all other eastern breeding specimens, as it has the characters that distinguish *clariterga.* It is not improbable that this is a straggler from the western range of this species that came east during one of the sporadic invasions that characterize the seasonal movements of the Red-breasted Nuthatch, and failed to return to its normal breeding grounds.

Specimens of Sitta canadensis clariterga examined are as follows. Total number, 46, from the following localities: *British Columbia*—Queen Charlotte Islands, 18 June 1900, ♀; 22 June 1900, ♀. *Alberta*—Banff, 31 August 1894, ♂; Moose Branch of Smoky River, 5 August 1911, ♂. *Washington*—Tacoma, 22 August 1897, 2 ♂, ♀; Yakima Indian Reservation, 27 July 1917, ♂; Yakima, 31 August 1957, sex (?); Mt. St. Helens, 11 June 1941, ♂; Mt. Adams, 15 August 1943, ♂; 17 August 1943, ♂; 20 August 1943, ♂. *Idaho.*—Coeur d'Alene, 8 January 1957, ♀; Moscow, 25 miles northeast, 11 June 1947, ♂; Moscow, 20 miles northeast, 17 June 1947, ♀; Moscow, 12 December 1956, ♂; 16 December 1956, ♂; 28 November 1957, ♂; Lake Waha, Nez Perce County, 20 April 1950, ♂; Potlatch, 4 April 1954, ♂; Headquarters, Clearwater County, 15 June 1951, ♂; 18 March 1956, ♂; 25 December 1956, ♂; Shoup, 5 June 1949, ♂; Lardo, 27 July 1913, ♂. *Montana*—Zortman, 29 July 1910, ♂; Benton, 5 August 1910, ♂; 6 August 1910, ♂; Crazy Mountains, 19 June 1917, ♂; Hilger, 3 August 1919, ♀; 4 August 1919, 2 ♀. *Oregon*—Ft. Klamath, 27 August 1882, ♂; Bourne, 4 August 1915, ♂; Disaster Peak, 11 June 1915, ♀; Steen Mountains, 22 August 1916, ♂; Paradise, 3 July 1949, ♂. *Wyoming*—Teton Mountains, 27 August 1910, ♂; Kendall, 31 July 1911, ♂. *Colorado*—Ft. Garland, 3 June 1873,

♀; Snake River, 25 August 1906, ♂. *California*—Mt. Shasta, 20 July 1898, ♂; Lassen Peak, 24 August 1898, ♂; Lyonsville, 29 May 1906, ♂. *Nevada*—Ruby Mountains, 21 June 1898, ♂. *New Mexico*—Mt. Capitan, 13 June 1899, ♀.

Vireo olivaceus caniviridis new subspecies.

Characters. Similar to *Vireo olivaceus olivaceus* but the olive green of the upperparts paler and with a gray wash, lacking in the nominate race; pileum lighter, olive gray in contrast to the mouse gray of *olivaceus;* the lateral narrow line of black faint and inconspicuous; underparts clearer white, with little or no yellowish olive on the sides and flanks. No appreciable size difference.

Measurements. Eight breeding males from Idaho: wing, average 81.9 mm. (extremes 81–83); tail, 56.5 (53–58); exposed culmen, 11.7 (11–12.5). Four breeding females from Idaho: wing, average 78.8 mm. (78–80); tail, 56.8 (54–58.5); exposed culmen, 11.6 (11–12).

Type. Adult male, No. 420939, United States National Museum (Fish and Wildlife Service collection), Moscow, Latah County, Idaho, 30 June 1952; Thomas D. Burleigh, original number 14763.

Distribution. Breeds rather locally throughout Washington, Idaho, and northern Oregon. Both during the breeding season and in migrations this vireo is found in the larger deciduous growth along the streams, so there are wide areas within its breeding range where it does not occur at any time of the year. Altitude is another limiting factor, for despite apparently optimum conditions at higher elevations, it has never been noted above 2,500 feet. Winter range undetermined. Accidental in Alaska (Middleton Island, 26 June 1956).

Remarks. Despite a limited range, the Red-eyed Vireos of the arid country of the northwestern United States are so uniform in their characters, and so distinct in appearance, that they justify recognition as a distinct race. Both in distribution and characters there is a marked parallelism with the Veerys *(Hylocichla fuscescens subpallidus)* of this region, the grayish coloration and the habitat requirements of both these species being much the same. An immature female taken 21 September 1951, at Clarkston, Washington, on the opposite side of the Snake River from Lewiston, Idaho, and an immature male taken at Moscow, 16 September 1957, both in fresh fall plumage, differ from breeding specimens in that they lack the gray wash of the upperparts. However, the paler olive green of the back and the olive-gray pileum readily identify them as *caniviridis.* A breeding male taken at Puyallup, Pierce County, Washington, west of the Cascades, is intermediate in its characters toward *olivaceus,* which form apparently extends across the continent to the coast of British Columbia north of the range of *cani-*

viridis. The olive green of the upperparts is perceptibly paler than in *olivaceus*, but there is only a faint trace of the gray wash characteristic of *caniviridis*.

Specimens of Vireo olivaceus caniviridis examined. Total number, 38, from the following localities: *Idaho*—Bonner County, Hope, 13 June 1903, ♀; Sandpoint, 21 June 1957, ♂; Kootenai County, Coeur d'Alene, 4 July 1949, 2 ♂♂; Benewah County, St. Maries, 22 June 1948, ♂; Latah County, Princeton, 30 May 1949, ♂; Potlatch, 21 May 1948, ♂; 4 September 1948, ♀; 19 July 1950, ♀ im.; 12 September 1951, ♀; Moscow, 11 August 1948, ♀; 27 August 1949, ♂; 7 September 1949, 2 ♀♀; 11 July 1951, ♂; 30 June 1952, ♂; 16 September 1957, ♂ im.; Nez Perce County, Lewiston, 24 July 1950, ♂; 6 June 1951, ♂; 21 August 1956, ♀; Lapwai, 12 July 1950, ♂; Culdesac, 30 June 1949, ♂; Clearwater County, Elk River, 25 June 1951, ♂; Orofino, 12 June 1951, ♂; Washington County, Cambridge, 4 June 1951, ♂; 7 June 1952, ♂; Boise County, Horseshoe Bend, 21 June 1950, ♂; Idaho County, Graves Creek, ¼ mile from the Salmon River, 17 June 1951, ♂; Whitebird, Lemhi County, 24 June 1958, ♂; Shoup, 5 June 1949, ♂. *Washington*—Spokane, 18 June 1948, ♂; 3 August 1948, ♂; Uniontown, 18 June 1950, ♀; Clarkston, 21 September 1951, ♀ im.; Columbia River, 10 July 1897, ♂; Wenatchee, 29 July 1955, ♂; Puyallup, 28 May 1954, ♂. *Oregon*—Homestead, 31 May 1916, ♂; Portland, 7 August 1957, ♀.

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GENERAL NOTES

Intramuscular Fat Store in the Pectoralis of Birds.—George (J. Univ. Bombay, 16: 3, 1947; J. M. S. Univ. Baroda, 1 (2): 25–33, 1952) studied the muscles of several representative vertebrates and noted the high fat content in the *pectoralis major* of the pigeon. George and Jyoti (J. Anim. Morph. Physiol., 2: 38–45, 1955) confirmed the high fat content in the pectoralis of the pigeon and found the same in the muscle of other birds (kite and parakeet). They also demonstrated (J. Anim. Morph. Physiol., 4: 119–123, 1957) that this fat forms the chief fuel during long and sustained contraction of this muscle. George and Scaria (J. Anim. Morph. Physiol., 3: 91–103, 1956) showed the presence of high lipase activity in the breast muscle of the pigeon and discussed its possible role in the utilization of fat as energy fuel in sustained muscular activity. In the light of these works, muscle fat assumes considerable importance. Some data collected on the percentage of fat in the *pectoralis major* of various birds are presented here.

All the birds obtained for this work were shot with an air rifle. Within 15 minutes of the death of the bird, a portion of the *pectoralis major* was cut into

FAT CONTENT OF THE *pectoralis major* OF BIRDS

	Per cent of fat, fresh weight	
Species	*Mean* ± *S.D.*	*Maximum*
Pied-crested Cuckoo *(Clamator jacobinus)*	6.3540(1)	
King Crow *(Dicrurus macrocercus)*	5.6422(4) ± 0.24	4.1380
Rosy Pastor *(Pastor roseus)*	4.7802(4) ± 0.34	5.2740
Hawk Cuckoo *(Hierococcyx varius)*	4.6075(2)	4.8310
House Crow *(Corvus splendens)*	4.1665(5) ± 0.63	5.2610
Blue-tailed Bee-eater *(Merops superciliosus)*	3.9850(2)	4.2570
Cattle Egret *(Bubulcus ibis)*	3.8985(4) ± 0.24	4.1380
White-breasted Kingfisher *(Halcyon smyrnensis)*	3.5537(4) ± 0.83	4.5080
Barn Owl *(Tyto alba)*	3.6900(1)	
Jungle Crow *(Corvus macrorhynchos)*	3.6130(1)	
Brahamini Myna *(Temenuchus pagodarum)*	3.4375(2)	4.2620
Golden Oriole *(Oriolus oriolus)*	2.8920(2)	3.0110
Hoopoe *(Upupa epops)*	2.7520(1)	
Mahratta Woodpecker *(Dendrocopos mahrattensis)*	2.6520(2)	2.8800
House Sparrow *(Passer domesticus)*	2.6302(4) ± 0.11	2.7660
CommonMyna *(Aeridotheris tristis)*	2.5330(2)	
Koel *(Eudynamis scolopaceus)*	2.4307(4) ± 0.42	3.0020
Red-vented Bulbul *(Molpastes cafer)*	2.1796(3)	2.2450
*Blue Rock Pigeon *(Columba livia)*	4.46	
*Pariah Kite *(Milvus migrans)*	4.80	
*Parakeet *(Psittacula krameri)*	5.33	
*Fowl *(Gallus domesticus)*	0.98	
***Batrachus* (fish) Body muscle	1.21	
***Rana* (frog) Leg muscle	0.90	
***Uromastix* (lizard) Leg muscle	1.40	
***Cavia* (guinea pig) Leg muscle	1.86	

*George and Jyoti (1955)
**George (1952)
(Figures in parentheses indicate number of estimations.)

small pieces, dehydrated in an air oven at 80°C., ground into fine powder, and transferred into a fat-extraction thimble. The fat was extracted with 1:1 ethanol-ether mixture in a soxhalet apparatus. Results obtained are presented in the table, and for the sake of comparison data on the muscle of vertebrates (adopted from George, 1952) and on the pectoralis of birds examined by George and Jyoti (1955) are also included. From these data it can be safely generalized that the *pectoralis major* of actively flying birds can be characterized by high fat content.

Fat deposition in the muscle is not only governed by the enzymatic systems in the muscle fibers but also by certain hormones in the peripheral circulatory system. Since both these factors appear to be equally important, a direct correlation between the amount of muscle fat and activity cannot be expected. Though utilization of fat in the flight muscles of birds, bats (George and Jyoti, J. Anim. Morph. Physiol., 5: 57–60, 1958), and insects (Weis-Fogh, Phil. Trans. Roy. Soc., B 237: 1–36, 1952) during long and sustained activity is now quite well established, the presence of a high percentage of fat does not mean that fat is utilized more in the muscle. But nevertheless it now appears certain that intracellular muscle fat serves as the reserve store of energy, which is mobilized and utilized when needed and continuously recharged from fat depots such as adipose tissue and liver.—J. C. George and R. M. Naik, *Department of Zoology, M. S. University of Baroda, Baroda 2, India.*

Note on the Palaearctic Robins.—In his review of Charles Vaurie's recent book, "The Birds of the Palaearctic Fauna" (Auk, 76: 442–444, 1959), my old friend, Professor Erwin Stresemann, praises the work as much as I would have myself. But he also deplores the author's use of broad genera. Although he does not name the "two enterprising authors" who started in America a "trend towards revolutionary generic consolidation," it is not difficult either to realize that I am one of them, or to guess who the other one is. He, however, admits that "proposals for drastic changes do no harm when advanced in special articles." I would like to point out that all the generic "lumping" adopted by Vaurie has been discussed before the issue of his work by himself, in his numerous papers in American Museum Novitates, and elsewhere, or by myself and other ornithologists in special published studies.

I am not proposing to discuss here the merits of wide genera. I have done so before. I will just remind the reader that generic terms are meant to point out relationship between species, not slight differences. "Time-honored" names, which tend to obscure and confuse relationship, simply should not be honored any longer when a better knowledge of the morphology and biology of the birds indicates affinities previously unnoticed.

My own criticism of Vaurie's book applies, on the contrary, to his excessive generic splitting of some of the Old World Robins. He very well understood the close relationship of the species in his paper on the systematics of the group (Am. Mus. Novitates, No. 1731, 10 June 1955), and it is a pity that he changed his mind later on, no doubt under outside pressure. It is totally inadmissible for anyone familiar with the birds in life to place in two distinct genera *(Erithacus* and *Luscinia)* the European Robin *(rubecula)* and the Japanese *(akahige)*. I have often observed these birds in the wild state and in aviaries. I actually have kept them for many years in contiguous compartments for the purpose of comparison. If it is true that the voice differs, all other biological characteristics agree closely. Indeed this difference in the voice is the only possible, if not too convincing, reason not to consider the two forms conspecific. The fact that the sexes are more differ-

ent in *akahige* than in *rubecula* is of little significance. I personally believe that the genus *Erithacus* should also include all the species placed by Vaurie in the genus *Luscinia* as there are no differences among them important enough to warrant generic distinction. It was even a greater surprise to find the species *sibilans* separated in the genus *Pseudaedon*. I have never seen this little Robin in its breeding territory, but it was a common winter visitor to northern Indochina, where I observed and collected it repeatedly. It is a Robin as much as any other species; the insignificance of the song and the color of the eggs do certainly not warrant generic distinction any more than in the case of *Phoenicurus moussieri*, for instance. It resembles very closely the female of *E. cyane*.

Authors who accept without argument the large genus *Turdus* for all the typical Thrushes, some of which differ even more among themselves than the comparatively few species of Robins do, should be consistent in including all the latter in the genus *Erithacus*.—J. Delacour, *Los Angeles County Museum, Los Angeles, California.*

First Records of Cattle Egrets *(Bubulcus ibis)* in Guatemala.—At about 2:30 p.m. on 24 April 1959, a Cattle Egret flew into the Cibal Aguada at Tikal, Peten, Guatemala. It was in the company of two mature Little Blue Herons *(Florida caerulea)* at the time. The taboo against collecting at this archeological site was temporarily lifted when the story of the comparatively recent spread of this active bird from Africa was explained. The bird was still there the next morning, and I collected it on 25 April 1959. The specimen is now at the Museum of Comparative Zoology, Harvard College. It was a mature male, with enlarged testes, and the crown and nape were a light, buff color. The bill was a clear, lemon yellow above but lighter or whitish yellow below. The tarsi and feet were black, contrasting with thighs of greenish yellow where exposed up to the feathers. The irides were yellowish white. Weight was 318.3 grams.

This appears to be a first record of the Cattle Egret in the Department of Peten, Guatemala. Tikal is a very recently "opened" area situated in heavy forest, with an airstrip only about four years old. There are no cattle in the area, which is located about 200 miles north of Guatemala City, at an elevation of about 500 feet.

Two other records for the Mexican part of Yucatan Peninsula were reported by Reginald Denham (Auk, 76: 359, 360, 1959).

Two other Cattle Egrets taken in Guatemala were reported to me, as quoted below by permission of Hugh C. Land. "We took two specimens in Guatemala, both from a flock of about fifty birds that could be seen almost daily in a meadow with a herd of cattle. The first skin was taken on November 6th, 1958. It was collected by a native and prepared by Larry Wolf, a student at the University of Michigan. The sex of the bird could not be determined. I took a female on January 12th, 1959. Both specimens came from an area five miles south-west of Panzós in the Department of Alta Vera Paz. The elevation here is about 200 feet above sea level. This locale is in the Polochic Valley, about thirty miles west of Lake Izabal."—Frank B. Smithe, *645 West 44th Street, New York 36, New York, and* Hugh C. Land, *University of Oklahoma, Norman, Oklahoma.*

Copulatory Behavior of the Red-headed Woodpecker.—On 16 May 1959, in Ann Arbor (Washtenaw County), Michigan, I observed the interesting position assumed by Red-headed Woodpeckers *(Melanerpes erythrocephalus)* during copulation. In preparation for the act, one of the birds, presumably the female, perched

Figure 1. Position of Red-headed Woodpeckers during copulation.

parallel on a limb, in typical woodpecker fashion, and remained motionless. The partner appeared and obtained copulatory position by clasping the side of the limb to the female's left with one, or possibly both, feet. The male then rotated his body so that the anus was upturned (see Figure 1). In this position the copulatory organs of the pair united, and the male exhibited a rapid, repeated, sideward motion lasting a few seconds. The female remained motionless. The active partner immediately flew from the tree and chased a third Red-headed Woodpecker that had neared the scene. Soon the abandoned female fluffed her feathers and flew in the direction taken by the male.

Kilham (Auk, 75: 322, 1958) described a similar copulatory position in his study of the Red-bellied Woodpecker *(Centurus carolinus)*. However, in that species "the male starts well-mounted, then gradually falls off to the left side and somewhat backward. . . ." It would be of interest to know if this side posture is also used in other species of woodpeckers. Perhaps such a posture is necessitated because of two factors: the female's habit of perching parallel to the branch; and the possession of stiffened rectrices by members of the Picidae. Perhaps the combination of these two factors prevents satisfactory union of copulatory organs in any other position.—WILLIAM E. SOUTHERN, *Department of Biological Sciences, Northern Illinois University, DeKalb, Illinois.*

Knot Collected Inland in Oregon.—On 6 May 1959, an injured Knot, identified as the American race *(Calidris canutus rufa)*, was collected on the gravel road that runs through McFadden's marsh, approximately 10 miles south of Corvallis, Benton County, Oregon. This bird had apparently been injured by flying into a wire fence parallel to the road. The author observed seven more of these Knots the same morning feeding on the edge of the marsh.

This is the first known record of this species east of the Coast Range in Oregon, although it is a rare migrant along the coast. In "Birds of Oregon" Gabrielson

and Jewett list this species as a rare migrant on Yaquina Bay. According to these authors, three specimens have been taken in Oregon since 1902, all at Seal Rocks, a few miles south of Newport on the coast: two on 19 August 1914 and the third on 31 August 1929. No Knot is known to have been taken in Oregon since that time. The Knot is common on the California coast and at times is abundant at Willapa Harbor, just to the north of the Columbia River, but it generally either fails to stop in Oregon or passes along the coast at sea.

This specimen is now (No. 5547) in the collection of the Oregon State College Museum of Natural History, Corvallis, Oregon.—KENNETH R. PORTER, *1713 Rainbow Avenue, Laramie, Wyoming.*

Worm-eating Warbler "Adopts" Ovenbird Nestlings.—On 17 June 1959, a nest of an Ovenbird *(Seiurus aurocapillus)* was found in Oakland, Bergen County, New Jersey. On 19 and 20 June I visited the nest for purposes of photography. The nest was on the ground among ground pine *(Lycopodium)*, under a dogwood tree *(Cornus)*, near the base of a wooded hillside, between 20 to 30 feet from a rough, unimproved, dirt road. At the time, four eggs were being incubated by an Ovenbird, which I photographed on the nest. A male Ovenbird could be heard singing nearby on both days and at one time approached and began to scold us when we neared the nest, while the female remained incubating. On 25 June I was told that the young had hatched. When I visited the nest on 26 June, I found four young being fed by one Ovenbird, which I photographed (Figure 1). I assume that this was the female, because she invariably approached the nest from the right, walking along the same route and in the same manner as I had observed during incubation. On returning for further photographs on 27 June, I noticed that two birds were now feeding the young and removing fecal sacs. The second bird proved to be a Worm-eating Warbler *(Helmitheros vermivorus)*. It was very wary in its approach, and would hop down to the nest instead of walking to it. Photographs were taken of this bird (Figure 2). I visited the nest again on 28 June and 1 July 1959, and on each occasion both the Ovenbird and the Worm-eating Warbler were observed feeding the nestlings, without any evident hostility. On one occasion, both the Ovenbird and the Worm-eating Warbler brought food to the nest at the same time, each feeding a different nestling. On another occasion, the female Ovenbird picked up a fecal sac and the Worm-eating Warbler tried to take it from her; both flew off, each with part of the sac. Additional photographs of each bird at the nest were taken on 1 July (Figures 3, 4). No second adult Ovenbird was observed near the nest at any time after the young hatched. On 3 July the young were gone. I did not observe either adult in the vicinity.—STANLEY J. MACIULA, *2 Springdale Court, Clifton, New Jersey.*

A Grasshopper Sparrow near Quebec, Province of Quebec.—On 28 May 1959, on a field trip to Charlesbourg, Quebec County, an unfamiliar bird song caught my attention. After a careful search through binoculars in a dry pasture, a small, sparrow-sized bird was noticed.

The bird was collected and proved to be a Grasshopper Sparrow *(Ammodramus savannarum)*. I referred it to *pratensis* after it was compared with specimens of the western race *perpilladus* in the collection of the Quebec Provincial Museum. The subspecific identity was confirmed by Mr. W. Earl Godfrey, Curator of Birds at the National Museum of Canada.

This seems to be a northeastward record for that species in the Province of

Figure 1. Ovenbird at nest with young.

Figure 2. Worm-eating Warbler at nest of Ovenbird containing young.

Figure 3. Ovenbird bringing food to young.

Figure 4. Worm-eating Warbler feeding young of Ovenbird.

Quebec. The author is aware of two previous records in the southwestern part of the province: the first one being recorded in the A.O.U. Check-list (1957), as breeding at Chambly Basin; and the second is a specimen preserved in the Quebec Provincial Museum collection. It was collected at Notre-Dame de Stanbridge (Iberville County) on 20 June 1953. These two localities are approximately 150 miles southwest of Quebec City.

The present specimen is now preserved in the collection of the author. It is a male whose skull is fully ossified. Its testes measured respectively 10.5 x 7.8 mm. and 11.5 x 6.0 mm. It has a very bright spring plumage.—Henri Ouellet, *341 Fourth Street, Quebec City, P.Q. Canada.*

Clutch Size of the Clapper Rail.—Incidental information concerning the clutch size of the Clapper Rail *(Rallus longirostris)* was obtained during other studies of this species in the extensive salt marshes near Chincoteague, Virginia. Clutches were considered complete when repeated visits to the nest showed no additional eggs or when embryonic development could be clearly detected.

The size of completed clutches was determined for 149 first or primary nests. Nineteen of these were found on 17 May 1951, nine on 4 June 1952, and 50 during the period 30 May–2 June 1953. Data for 71 nests found during 25 May–9 June 1950 (Stewart, 1951), were included also. The number of nests for each clutch size was:

4 eggs—	1 nest	(0.7%)	9 eggs—	43 nests	(28.9%)
5 eggs—	4 nests	(2.7%)	10 eggs—	39 nests	(26.2%)
6 eggs—	5 nests	(3.4%)	11 eggs—	21 nests	(14.1%)
7 eggs—	13 nests	(8.7%)	12 eggs—	1 nest	(0.7%)
8 eggs—	22 nests	(14.7%)	*Total*—	149 nests	(100.0%)

Nests with nine eggs represent the largest clutch-size class, closely followed by those with 10 eggs. The mean clutch size was 9.00 ± 0.19 eggs. This is somewhat lower than mean clutch sizes reported from New Jersey and North Carolina, and higher than the clutch size recorded from Georgia. In New Jersey, "the average number of eggs per clutch in 1948, 1949 and 1950 was 9.9, 10.00 and 9.3 respectively, based on 176 completed clutches" (Schmidt and McLain, 1951). Additional data from New Jersey include a mean clutch size of 9.86 ± 0.24 (range 3–14) based on 43 nests (Stone, 1937), and a mean of 10.05 ± 0.26 (range 5–14) based on 61 nests found in 1948 by Kozicky and Schmidt (1949). In North Carolina, a mean clutch size of 10.5 ± 0.29 (range 9–12), based on 13 nests found in 1956, was reported by Adams and Quay (1958). The low clutch size in Georgia was reported by Oney (1954), who recorded an average of 8.2 eggs per nest, with a range of 5–14 eggs, apparently based on about 100 nests in three years.

The full clutch size in 16 replacement or secondary nests in the Virginia area also was determined. These represented nests that were constructed by breeding pairs following the destruction of their first nests through predation or action of severe high tides. They included 13 nests found near Chincoteague during the period 20 June–27 June 1959, and three nests found near Cobb Island on 10 August 1951. The mean clutch size of this series was 5.62 ± 1.06, which is 3.38 less than the mean for the first or primary Virginia nests. This difference can be considered to be statistically significant. The number of secondary nests for each clutch size was:

3 eggs—1 nest (6.2%)	7 eggs— 1 nest (6.2%)
4 eggs—2 nests (12.5%)	8 eggs— 1 nest (6.2%)
5 eggs—5 nests (31.2%)	9 eggs— 1 nest (6.2%)
6 eggs—5 nests (31.2%)	*Total*—16 nests (100.0%)

Apparently, five and six eggs represent the prevailing clutch-size classes for secondary nests. These data appear to be at variance with a statement by Oney (1954), who found no "appreciable decrease in the size of the clutch toward the end of the nesting season" in Georgia.

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—Robert E. Stewart and Brooke Meanley, *Patuxent Research Refuge, Laurel, Maryland.*

Unusual Responses of a Prairie Warbler to Sunlight.—The occasional suddenness of the initiation of sun bathing in birds and the striking way in which sunning may take precedence over feeding behavior have been described by Hauser (1957). Responses to sunlight by a female Prairie Warbler *(Dendroica discolor)* observed at Bloomington, Indiana, are interesting in this connection for two reasons: first, the dominated activity was probably the gathering of nest material; second, the bird attempted to hop while in a sun-bathing position, with the result that she moved as though crippled. The observations were made on 28 May 1959, at 11:00 A.M., when the sky was unusually bright and the air temperature was about 80°F. The warbler had just lost her second nest to a predator, and although her third nest was not found until four days later, she had probably begun its construction when the following behavior was witnessed.

When discovered, the bird was perched on a low branch in partial sunlight, her bill open, her wings half spread, her tarsi slightly flexed. A similar rigid attitude often denotes hostility in the Prairie Warbler, but this female was periodically giving her attention to normal preening and did not appear to be tense. In retrospect, it seems likely that she was in the shading position, heretofore seen by me only at the nest, where it usually functions to shelter nestlings from direct sun.

After about a minute, the warbler hopped to the nearly bare ground, in full sunlight. Here she immediately tilted her body to one side and assumed a sunning position corresponding to that designated by Mrs. Hauser as "level III" (see illustrations 2 and 3, *op. cit.*, p. 86). The warbler remained thus for some three seconds, flew to perch in the shade, and in about two minutes returned to the ground. This time she fell into a crouch, resting her belly on the ground, spreading

her wings wide to each side, and fanning her tail (much as in Mrs. Hauser's "level IV," illustration 5, *loc. cit.*). This posture was quickly replaced by that first mentioned, and after perhaps five seconds the bird retreated to perch in the shade. Again she waited a minute or so and then once more dropped down, but this time, although she went quickly into the crouched, wings- and tail-spread position, she attempted to hop about. The resulting movements were spasmodic and suggested that she was seriously injured. Her belly and spread wings dragged, so that she progressed in jerks and with difficulty and sometimes seemed about to lose her balance and topple forward. This performance lasted several seconds; she then flew up to sit quietly on a shady branch for two minutes. A final visit to the ground duplicated the preceding one, and after struggling along, apparently nearly helpless, for about a foot the bird flew up to a tree, joined her mate, and left. The entire episode lasted some eight minutes.

Feeding is arrested in many species, as described by Mrs. Hauser, when birds are suddenly subjected to the stimuli for sun bathing, but apparently little is known about the effects of the motivation to sun bathe (see Lanyon, 1958) on other kinds of behavior. Sunning birds are sometimes capable of hostile vocal and other responses, and such maintenance activities as preening and scratching are frequent (Hauser, *op. cit.;* Miller, 1952). The ability to fly to avoid the sunlight or to escape human intrusion seems to be not in the least affected, even in birds that appear to be suffering or comatose (Hauser, *op. cit.*). In the case of the Prairie Warbler described above, the behavior interfered with was very likely the gathering of nest material. Foraging on the ground is relatively rare, and all the circumstances strongly support the probability that the female was about to search for plant fibers.

Whatever the activity that yielded precedence to sunning, the fact that the bird appeared to be injured has some relevance to the subject of distraction display, although her behavior was quite different from this display in the Prairie Warbler. In the first place, there is the widely held view (discussed in Nice, 1943, and Armstrong, 1947) that the distraction behavior of some species is derived from the effort to respond simultaneously to stimuli calling forth highly dissimilar movements. The incident described above seems to be a good illustration of how reactions to conflicting stimuli can result in a product resembling the distraction display of many species. Second, the observation indicates the importance of caution not only in concluding that a bird "feigning injury" is engaging in distraction display but also in classifying any single instance of behavior, even though it is very striking, as display in the sense connoting stereotyped reaction.

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—Val Nolan, Jr., *Indiana University, Bloomington, Indiana.*

Surf Scoter in New Mexico.—On 30 October 1959, while driving north on U.S. Highway 85 two miles south of Los Lunas, Valencia County, New Mexico, I saw a car strike a dark-colored bird. The bird was examined and found to be an immature female Surf Scoter, *Melanitta perspicillata*. Examination indicated that the bird was already dead when struck by the car. The weather in the area as well as to the west into Arizona and California had been severe during the two previous days, with wind, and precipitation of over one inch. A study skin of the bird has been prepared and is in the collection of the New Mexico Department of Game and Fish. This appears to be the first reported occurrence from New Mexico.—WM. S. HUEY, *Box 4201, Santa Fe, New Mexico.*

Subspecific Names of Mexican Brown Jays: A Correction.—At the conclusion of a recent analysis of polymorphism in *Psilorhinus morio* (Auk, 76: 385–417, 1959), I apparently erred in assigning racial names to northern populations. Following current usage (cf. Davis, Condor, 53: 152–153, 1951), the name *Pica morio* Wagler (Isis von Oken, 1829: col. 751) [= *Psilorhinus morio morio* (Wagler)] was applied to the monomorphic brown population distributed from Tamaulipas and Nuevo León south to central Veracruz, while the name *Pica fuliginosa* Lesson (Traite d'Ornith., livr. 5: 333, 1830) [= *Psilorhinus morio fuliginosus* (Lesson)] was applied to the polymorphic population ranging from the coastal plain of central Veracruz south and east to Tabasco and Chiapas. Nomenclaturally, this would be correct, if, as formerly believed, the type locality of *P. morio* Wagler were Jalapa, Veracruz. But Stresemann (Condor, 56: 89, 1954) has indicated that the type actually came from Alvarado, on the gulf coast about 37 miles southeast of Veracruz City. Since Alvarado lies well within the range assigned to the polymorphic subspecies, this race must be known as *Psilorhinus morio morio* (Wagler).

For the northern monomorphic brown race, the name *Psilorhinus morio palliatus* van Rossem (Bull. Mus. Comp. Zool., 77: 415, 1934) is available. *P. fuliginosa* Lesson, with type locality "Mexique," could be considered to apply to the northern race; but, since this name has always been used for southern birds, it seems desirable to consider it a synonym of *P. morio* Wagler, as van Rossem *(loc. cit.)* has already suggested. The type of *P. fuliginosa* is no longer available for examination, and its precise locality of collection cannot be determined. To settle the matter once and for all, I hereby designate Coatzacoalcos (Puerto México), Veracruz, as restricted type locality of *P. fuliginosa* Lesson.—ROBERT K. SELANDER, *Department of Zoology, University of Texas, Austin, Texas.*

Some Observations on the Distribution of the Blood Capillaries in the Pigeon Breast Muscle.—The *pectoralis major* of the pigeon is a mixed type of muscle, in which the red and white fibers, which are structurally as well as physiologically well-defined and distinct types, exist side by side. The red fibers, narrower in diameter, are loaded with fat, whereas the white fibers, broader and poor in fat, are loaded with glycogen (George and Naik, Nature, 181: 709–710, 1958; Biol. Bull., 116: 239–247, 1959). The red color of the narrow, red fibers is due to the presence of oxygen carriers like myoglobin and cytochromes, which in the white fibers appear to be absent and if at all present, only in extremely low concentration. Since the mitochondrial content of the red fibers is also much higher than that of the broad fibers (George and Naik, Nature, 181: 782–783, 1958), the oxidative processes are much better developed in the red fibers than in the white

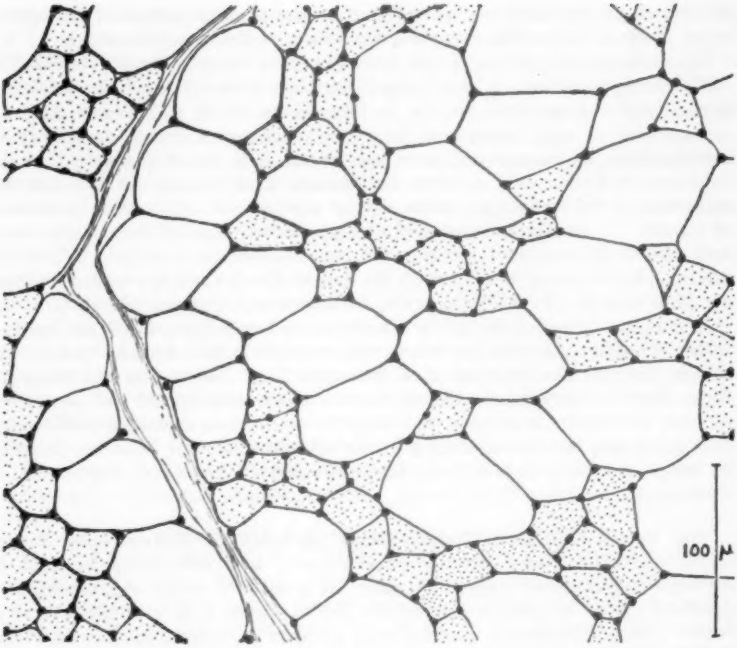

Figure 1. ***Camera lucida*** **sketch of t.s. of the** ***pectoralis major*** **of the pigeon injected with India ink to demonstrate the distribution of blood capillaries (seen as solid, dark dots at the periphery of the muscle fibers). The red, narrow fibers are shown dotted, while the white, broad ones are clear.**

ones. In the light of these observations, the distribution of the blood capillaries in the *pectoralis major* of the pigeon should be of considerable interest.

Dilute India ink was injected into the heart of several anaesthetized pigeons. After allowing the ink to circulate for a short time, the skin over the pectoralis was removed, and the bird was immersed in 10 per cent neutralized formalin for an hour, at the end of which small pieces of the *pectoralis major* were cut out and immersed in fresh formalin solution for 24 hours and then embedded in gelatin for sectioning according to the method of Clark (J. Path. Bact., 59: 337, 1947).

The accompanying figure shows the distribution of blood capillaries as seen in a cross section. Each fiber, red as well as white, is in contact with about five-six blood capillaries. Due to the bigger size, the surface area per unit volume of the broad fiber (diameter 69μ) is considerably less than that per-unit volume of the narrow fiber (diameter 30μ). With the number of capillaries surrounding a broad fiber about the same as that around a narrow fiber and the diameter of all the capillaries and rate of flow of blood through them presumed to be the same, it

can be concluded that the rate of supply of oxygen per gram weight of the narrow fibers is much higher than that per gram weight of the broad fibers.

The investigations of George and Jyoti (J. Anim. Morph. Physiol., 4: 119–123, 1957) on the *pectoralis major* of some flying birds show that fat is the chief fuel during long and sustained activity in these birds. It is well known that, on oxidation of an equal amount of fat and glycogen, over double the energy is obtained from the former than from the latter. It is also well known that the oxidation of fat not only demands considerably more oxygen but also that the utilization of fat for energy, unlike that of glycogen, is not possible in absence of oxygen. A partial breakdown of glycogen with release of energy can occur under anaerobic conditions, whereas the conversion of fat is strictly an aerobic process. In the pigeon breast muscle the narrow fibers, which are more numerous, are ideal sites for fat utilization. On the other hand, glycogen should form the chief fuel for the contraction of the less-numerous broad fibers, which are supplied with oxygen at apparently lower rate and are poor in mitochondrial content. If this is the case, the contribution of the white fibers during long and sustained flight should be very small; but on the other hand, they should well be able to perform a short series of quick and powerful contractions expending considerable energy, as may be expected during a take off when the wing beats are liable to be faster and more powerful.—J. C. George and R. M. Naik, *Department of Zoology, M. S. University of Baroda, Baroda 2, India.*

The Brown Cachalote, *Pseudoseisura lophotes*, in Bolivia.—The Brown Cachalote, *Pseudoseisura lophotes* (Reichenbach), is a well-known furnariid of northern Argentina and western Uruguay. It is about 10 inches long, crested, and generally rufous in color, and is notable for its domed stick nest "the size of a barrel," "made with enough material to fill a barrow" (Hudson, Birds of La Plata, 1: 232, 1920).

In Reichenbach's original description of *Homorus lophotes* (Handb. spec. Orn., cont. x, Scansoriae A. Sittinae: 172, 1853), the origin of his type specimen was given as "Bolivia" with a query. I have been unable to determine why Reichenbach questioned the source of this type (which was destroyed in World War II). Hellmayr (Cat. Bds. Americas, 4: 183, 1925) considered "Bolivia" as "no doubt incorrect," and Peters (Check-list Bds. World, 7: 122, 1951) called it "probably erroneous." These later authors may well have considered "Bolivia" an erroneous locality not only because of Reichenbach's query, but because the species was not otherwise known from the country of Bolivia. It is not listed in any of the major papers on Bolivian birds.

Carnegie Museum possesses four specimens of *Pseudoseisura lophotes* collected by José Steinbach on 23 and 25 August 1909 and 25 September 1915, at Guanacos, Province of Cordillera, Dept. Santa Cruz, Bolivia (approximately 32 km. east-southeast of Cabezas), altitude 700 meters. These appear to be the only known Bolivian specimens of the species, but they serve to prove that the Brown Cachalote does, indeed, occur in Bolivia. The four specimens have been compared with 39 from Argentina, representing the combined Carnegie Museum and American Museum of Natural History series, and prove to be subspecifically separable. It is conceivable that *Pseudoseisura lophotes* may ultimately be found to occur elsewhere in Bolivia, and it thus seems desirable to establish a restricted type locality for nominate *lophotes*. I therefore so designate Guanacos, the one Bolivian locality from which the species is now known.

Although the Argentine race is technically the "new" one and must be named, it is, of course, the well-known one and well represented in museums. I shall therefore reverse the usual descriptive comparisons and describe the characters by which the Bolivian (nominate) race is distinguishable from the Argentine.

To generalize, the Bolivian specimens are everywhere paler, with lighter brown and rufous colors. Specifically, in the Bolivian birds:

1. The long, anterior crest feathers are more gray-brown, less blackish, with the longest feathers relatively broader. In all specimens of this species, the anterior crest feathers are dark, the posterior rufous; in Bolivian birds there are more long rufous (*i.e.*, fewer dark anterior) feathers in the crest.
2. The upperparts in general (nape, sides of face and neck, back, rump, upper tail coverts) are paler rufous.
3. The tertials are paler, more rufescent (less blackish) brown.
4. The rectrices are paler, the central pair having shafts hardly darker than the webs (in Argentine birds the shafts of the central rectrices are blackish brown).
5. The general tone of the underparts is paler, but this is more subtle than the difference in dorsal coloration; best marked on throat and under tail coverts.
6. The throat and under tail coverts are not only paler rufous, but have the light tips of fresh feathers less whitish, contrasting less with the ground color.

The darker bird, which occupies the range as given by Peters *(loc. cit.)* for the species as a whole, may be called:

Pseudoseisura lophotes argentina, new subspecies.

Type: Carnegie Museum No. 137487; adult male in freshly molted plumage, collected at La Cocha, Tucumán, Argentina, 9 August 1956, by Claes Chr. Olrog.

The type specimen is one of a small collection of Argentine birds obtained by Carnegie Museum through the generosity of Dr. F. W. Preston. Specimens in the American Museum of Natural History were examined through the courtesy of Dr. Dean Amadon.—KENNETH C. PARKES, *Carnegie Museum, Pittsburgh, Pennsylvania.*

A Texas Record of the Black Brant.—The A.O.U. Check-list (5th ed., 1957, p. 64) lists the Black Brant *(Branta nigricans)* as of only casual occurrence in Texas. Wolfe (Check-list of the Birds of Texas, 1956, p. 14) gives only one record of a bird shot in Tom Green County in 1884 and a sight record near Brownsville in 1938. On 28 December 1956, I was goose hunting in Wilbarger County, Texas, about 15 miles south of Vernon. An adjacent hunter, whose name I did not learn, shot a black goose from a flock of Canada Geese *(Branta canadensis)* that had been decoyed to a typical wheat field pit blind. This goose was picked out and shot because it was observed to be entirely different from any of the other geese in the flock. Recognizing that any brant was an unusual species for Texas, I secured the bird as a specimen. It was still warm when it came into my possession. A colored photograph of this bird has been identified by Dr. John W. Aldrich as being *Branta bernicla nigricans.* Unfortunately, neither I nor the taxidermist sexed this specimen. The mounted bird is now in my possession.—J. C. HENDERSON, *Box 5132, Midland, Texas.*

Two Significant Calling Periods of the Screech Owl.—In 25 years of casual and serious studies made on the common Screech Owl, *Otus asio naevius,* in my neighborhood of Kripplebush in Ulster County, New York, I have been able to piece together definite information on the calls of the local population of this little

owl. In checking considerable ornithological literature, I have been unable to find reports of two calling periods relative to the time of year. Bent, in his "Life Histories of North American Birds of Prey," Part 2, has given an interesting account of Screech Owl calls, but no mention is made of seasonal differences in calling habits. For so common a little owl, it seems incredible that these calling periods have escaped the attention of ornithologists and naturalists.

Sometime during middle or late January, the Screech Owl at this latitude begins the spring "mating call," *who-who-who*. Infrequent at first, this "mating call" may become a nightly owl song period by March and through April. I have not noted much variation in this spring "mating call," the mellow-sounding *who-who-who's* remaining about a steady tone, with a slight inflection, lasting a few seconds to die away abruptly and a little later repeated. During May and June, the call is not heard with regularity. By July, the young are fully fledged and are sometimes heard giving their guttural calls. The "mating call" at this time has decreased in frequency and is replaced by the familiar tremulous whistle or so-called "screech" that becomes the regular call from this period until January. That the tremulous whistle is often followed by a *who-who-who* closely resembling the "mating call" is cause for some confusion, but the nature of its delivery as compared with the spring call is sufficiently altered so as to make differentiation possible.

My observations indicate that Screech Owls have two distinct call periods summarized as follows: After a brief period of silence in early January, the "mating call" is started and used throughout the spring months and until mid-summer. No "screech" is used during this time except during the mid-summer change-over when both calls may be heard. As the change-over is completed, the "screech" becomes the regular late summer and fall call, lasting until January when again the calls are switched.—FRED HOUGH, *Accord 1, New York.*

Coloration of *Pharomacrus mocino*.—The present note is to put on record some observations made a number of years ago that I am no longer in a position to repeat or confirm. It is my hope that someone with access to an electron microscope and a spectrophotometer will do this. Similarly, I am not able to document properly some observations and references to literature.

The basic facts are that the male quetzal is largely brilliant green above and bright red below and that these two colors are very nearly complementary. The apparent color of the upperparts varies with the angle of view and of incidence of the light from red to deep blue. The relation between angle and color is that proper to interference colors. The underparts show no indication of interference colors. Professor Hans Mueller (Massachusetts Institute of Technology) agreed that the main color of the upperparts was caused by interference but that there might be a trace of diffraction color. The latter source is common in insects but has never been found in birds.

The ventral red feathers contained a pigment whose solubility and color indicated that it was probably a carotenoid.

The barbules of the dorsal feathers viewed by transmitted light under the microscope were "blood" red. No granulation of the pigment was seen. So far as I know the pertinent literature, those feathers that show interference colors are stated to be pigmented with melanin, and this pigment occurs in discrete granules resolvable with the light microscope. I could find no pigment whose solubility suggested carotenoid. A caustic digest yielded a dispersion whose absorption spectrum was nearly the same as that from an appropriately diluted digest of

feathers of *Corvus brachyrhynchos.* A photograph taken with the electron microscope in Professor C. E. Hall's laboratory (Massachusetts Institute of Technology) suggested strongly the presence of discrete granules well below one micron in diameter.—CHARLES H. BLAKE, *Museum of Comparative Zoology, Cambridge, Massachusetts.*

An Unusual Winter Plumage of the Goldfinch.—Each winter, a number of Goldfinches *(Spinus tristis)* come to the feeding station in my yard. On 16 February 1959, I first noted a bird, presumably a male, that had retained the black crown and forehead characteristic of the summer plumage of the male. The bird has reappeared this winter, being first seen 30 November 1959, and still present as I write this on 20 January 1960.—ARETAS A. SAUNDERS, *Canaan, Connecticut.*

REVIEWS

Complete Field Guide to American Wildlife/East, Central and North. —Henry Hill Collins, Jr. 1959. Harper and Brothers, New York, N. Y. xix + 683 pp., 48 col. pls., many figs. Price $6.95.—Included are birds (they come first), mammals, reptiles, amphibians, food and game fishes, seashells, and principal marine invertebrates "occurring annually" in North America east of the Rockies and north of the 37th parallel.

Birds—249 pp., 28 col. pls., etc. The boiling-down process, to try to crowd in everything, including irrelevant material, has resulted in numerous brief generalities in text instead of really diagnostic information. By cutting down on such useful components as adequate comparisons with confusing species, room has been made for sundry quotations (Shakespeare, Whitman, *et al.*, rather heavy on Kipling) and bits of useless information (Bachman's sons married Audubon's two daughters). These might get by in a bedside book, not a field guide. The small range maps are rather useful. The color plates (turn to mammal section for four of them) leave the sort of impression one might get on seeing Roger Peterson's work imitated poorly, with figures sometimes reversed, rearranged, and scale ignored. On one plate Cooper's Hawk is longer than Black Vulture!

Although other sections of the book are largely outside the scope of this review, perhaps it should be mentioned that the only features that tend to approach the high standards set by the best available guides are Yrizarry's plates of reptiles and amphibians.—Ralph S. Palmer.

Birds of the Belorussian Forestland.—M. S. Dolbik. 1959. Minsk. 268 pp., 50 line drawings and photoreproductions, bibliography. (In Russian: no foreign language summaries.) $1.90. Victor Kamkin, Washington, D.C.—The Belorussian forestland constitutes approximately 12 million hectares of watery lowland between the Dnepr and Bug rivers, drained by the Pripet River and its many tributaries. On the map it forms a rough triangle between Brest (to the west), Minsk (to the north), and Gomel (to the east). The area is frequently labelled "Pripet Marshes." It contains deciduous, coniferous, and mixed woodland with a substantial amount of swamp, river bank, meadow, and agricultural habitat as well.

On the basis of seven years (1948–1956) of collecting and observational field work plus a review of literature, the author describes the status of 250 species in the area, 192 of which breed there. The amount of data recorded for each reflects the bird's rarity or abundance. For the Lesser White-fronted Goose *(Anser erythropus)*, for example, there is the cryptic comment: "Rarely encountered on migration. There is one known record of a bird taken October 9, 1927 by I. N. Serzhanin in the vicinity of Lyuban in the Minsk Oblast'." On the other hand, there are several pages on the Black Tern *(Chlidonias nigra)*, a very common breeding species.

In addition to the annotated list, which forms the bulk of the book, there is: a brief chapter on the climate and general natural history of the area; a chapter on habitat disposition including a tabular arrangement of the breeding birds with respect to 19 specific different habitats where they occur; a chapter of zoogeographic analysis centered on a discussion of the history of the formation of the avifauna of the area; and a helpful bibliography. As in other Soviet regional studies, this book has quite a few notes on stomach contents of the species collected.

This is an inexpensive, unpretentious book, written in a clear, terse manner.

As the swamps of Pripet are drained, the woods cleared, and settlement extended, the bird life in this area will continue to change. (As the author points out, it has been doing this slowly since Shnitnikov's review of the birds of Minsk in 1913.) This book will be permanently useful as a sound presentation of the ornithological status quo of the Pripet marshes at midcentury.—D. G. NICHOLS.

Las Aves Argentinas. Una Guia de Campo.—Claes Chr. Olrog. 1959. "Miguel Lillo," Universidad Nacional de Tucuman, Tucuman, Argentina. 343 pp., 48 col. pls., numerous maps and text figs. 150 Argentine pesos (about $1.70).—Visitors to South America are constantly inquiring about bird identification books. Aside from the excellent two volume "Las Aves de Chile," which covers a peculiar and small avifauna, there has been no modern work useful in field identification. The present book is designed as a field guide covering the over 900 species included in the avifauna of Argentina, ranging from numerous tropical species in the north to birds breeding in that large segment of Antarctica and the South Atlantic islands (including the Falklands and dependencies) claimed by Argentina. Dr. Olrog has provided drawings in color of each species; the text gives Argentine and scientific names, distinguishing characters, data on field recognition (including habitat), Argentine subspecies and their distribution, plus a small map showing range within Argentina of the species as a whole. Getting a vast number of species into a small pocket-sized volume required the text to be severely compressed, so that only two or three lines are usually devoted to description of a species. Nevertheless, with the accompanying illustrations, field identification should be feasible in most cases. Dr. Olrog is an ornithologist, not an artist, and his schematic drawings are amateurish; in some instances the poor color reproduction may prove misleading. But the book is unique in its field, and the price is extremely modest. It should prove tremendously useful not only to the people of Argentina and to visiting bird spotters, but also to ornithologists. In addition to the main text, which in itself is an up-to-date Argentina check-list, there is a convenient separate list of the 1,131 forms included in the avifauna, a tabular summary of the number of species and forms in each family (with indication of the breeding area of migrants and casuals), and an introductory chapter on Argentine zoogeography and habitats. As a final convenience to the tourist, there is a Spanish-English glossary covering the simple vocabulary of the text.

This book should be useful not only in Argentina, but also in southern Brazil, Uruguay, Paraguay, Bolivia, Antarctica, and to some extent in Peru and Chile. It is a pity, therefore, that the extra-Argentine ranges of the species treated were not briefly indicated. The guide will contribute to increasing popular interest in Argentine birds both within and without the country. The author and the Instituto "Miguel Lillo" thus deserve the gratitude of conservationists and bird students for making this work available at a price that all can afford.—E. EISENMANN.

Ein dritter *Archaeopteryx*-Fund aus den Solnhofener Plattenkalken von Langenaltheim/Mfr.—Florian Heller. 1959. Erlanger Geologische Abhandlungen, Heft 31, 25 pp. with 15 pls. and two text figs. (Obtainable from the Geologisches Institut der Universität Erlangen, Schlossgarten 5, Erlangen.) 20 Deutsche Mark.—In the preface to de Beer's monograph on *Archaeopteryx*, W. H. Edwards expressed doubt as to whether another specimen of this unique bird could be expected from the intensively collected Solnhofen quarries. In 1956, however,

another skeleton of *Archaeopteryx* was discovered in the quarry of Eduard Opitsch in Langenaltheim, Bayern, the site being only 250 meters from that of the London specimen. Because of its poor state of preservation, the fossil did not arouse much interest among the local workers, and it was not until 1958 that it was shown to Klaus Fesefeldt, a student at the Geologisches Institut der Universität Erlangen, who immediately conveyed the information to the University. Arrangements were made to have the specimen brought to Erlangen where it was studied by Professor Heller. The results of his study are given in this paper.

The first question that arose was whether the new find came from the same level as the London specimen. For the answer to this question, Professor Heller turned to Klaus Fesefeldt, who had made an intensive study of the stratigraphy of the Solnhofen limestones. Fesefeldt determined that the stratum in which the new specimen was found lies about six meters above the layer in which the London specimen was discovered. This indicates that *Archaeopteryx* had occurred in the Solnhofen region for some time and that the chances of uncovering more specimens may be better than formerly believed.

Because many of the bones were badly fractured, preparation of the fossil was limited to the removal of a thin film of limestone from the surface of the counterslab and the excavation of a few bones, such as the left humerus, on the counterslab. However, several photographic techniques were used extensively. Both slabs were photographed with normal light, including the use of shadow effects and stereophotography, and with ultraviolet light, which causes the bone to fluoresce. The slabs were also x-rayed, which led to the discovery of several concealed elements. By the use of these techniques, Professor Heller was able to study the fossil so thoroughly that it is extremely doubtful that future workers will be able to add anything new to his findings.

The new *Archaeopteryx* fossil consists of two slabs, with most of the bones being found on the counterslab. Unfortunately, the bird was in an advanced state of decomposition by the time it was finally covered with sediment, so that a good part of the skeleton is missing, and most of the remaining bones are disarticulated. The bones are not spread out as in the London and the Berlin specimens, but they are clustered together and frequently lie over one another. The preserved and identifiable bony elements are as follows: the vertebral column with the exception of the caudal vertebrae, most of the bones comprising both forelimbs, one scapular, most of the furcula, and parts of the hind limbs. In addition, there are scattered pieces of ribs and other bony scrap. The head, tail, pelvic girdle, and most of the pectoral girdle are missing. The feather impressions are poor; indeed, they show little more than the presence of feathers. All preserved elements were carefully described, illustrated with numerous photographs and line drawings, and compared with the London and Berlin specimens. The new specimen agrees with these older specimens in all essential details. In size, it is almost identical with the London specimen. Even though the new find is in a poor state of preservation as compared with the previous finds, Professor Heller was able to uncover several important new features in the structure of *Archaeopteryx* and confirm several others. One of the most important features of the new find is that, for the first time, the tarsometatarsus can be seen from the frontal plane. The metatarsi of the three anterior toes lie next to one another and have started to fuse together to form a true tarsometatarsus; they are not separate as previously suspected. The other important find is that the long bones are hollow and doubtlessly pneumatic. This can be seen clearly in many bones because of the great amount of

fracturing. In the previous specimens, the bones were not broken, and because no pneumatic fossae were found, it was naturally concluded that the bones were nonpneumatic. In addition to these new finds, a complete furcula and an almost complete fibula (the extreme distal end is lacking, but this is probably due to immaturity or poor preservation) were found. The body vertebrae are amphicoelous as can clearly be seen in the x-ray photographs; however, the articular surfaces of the cervical vertebrae could not be seen clearly.

Professor Heller concluded that the recent find should be referred to the species *Archaeopteryx lithographica* and agreed with de Beer that *Archaeopteryx* should be considered a true bird, although it is probably ancestral to all other birds, and that it dwelt in trees. The discovery of this fossil also raises our hopes that more specimens may be found and that perhaps we may eventually learn more about the structure of such poorly known features as the sternum and parts of the skull. Ornithologists are certainly in the debt of Eduard Opitsch and his workers for the discovery of this new specimen of *Archaeopteryx*, to Klaus Fesefeldt for his part in bringing the attention of the scientific world to the fossil, and especially to Professor Heller for his masterly investigation of this third specimen of *Archaeopteryx*.—Walter J. Bock.

The Waterfowl of the World. Vol. 3.—Jean Delacour. 1959. Country Life Limited, London. 270 pp., with 20 col. pls. by Peter Scott and 46 distribution maps. Six guineas.—This volume concludes the systematic review of the Anatidae, covering the eiders *(Somateriini)*, the pochards *(Aythyini)*, the perching ducks *(Cairinini)*, the scoters, goldeneyes, and mergansers *(Mergini)*, and the stiff-tailed ducks *(Oxyurini)*. The systematic arrangement follows closely that of Delacour and Mayr published in The Wilson Bulletin (57 (1): 1945). An important exception is the separation of the eiders from the Tribe *Mergini*, following recent recommendations by P. S. Humphrey, based on a study of tracheal morphology, plumage patterns, and food habits. This new arrangement reflects the view that the eiders and pochards arose as independent lines of evolution from the dabbling ducks *(Anatini)*.

As in the two previous volumes, most of the space is devoted to discussions of general habits, courtship and breeding behavior, and response to captivity. The author not only draws heavily on his extensive personal experience with many forms, but quotes extensively from private correspondence as well as from published accounts. Attention is called to unfilled gaps in our knowledge of the habits and breeding biology of various forms, a feature of no little importance and a challenge to future observers.

In the case of migratory species, the distribution maps show the breeding range and winter range as sharply delimited areas, giving the impression that there is never any overlap. The hallux (p. 43 and elsewhere) is inexplicably called the "thumb." As usual, the splendid color plates by Peter Scott are an attractive and useful feature of this important work. This is especially true of the 54 figures of downy young.

Although the book is handsomely printed, illustrated, and bound, the price of six guineas (about $17.64 U.S.) seems very high for a volume of less than 300 pages. It appears likely that a 50 per cent reduction in price would increase the sales several hundred per cent, thereby reaching a much wider audience and perhaps increasing the net returns to the publisher.

The fourth and last volume is expected to cover such topics as morphology,

anatomy, and biology of the family, history, sport, care and breeding, and bibliography—George E. Hudson.

Vara Faglar i Norden. Vol. I (Revised Ed.).—Kai Curry-Lindahl, editor. Bokförlaget Natur och Kultur, Stockholm. 557 pp., 40 figs., 373 black-and-white photographs, and 85 col. pls.—Volume I of the very extensively revised edition of this well-known popular treatise of the birds of Scandinavia and Finland contains preliminary sections on morphology and anatomy (pp. 11–21) and investigations on migratory species (pp. 22–28). The remainder of the volume consists of treatises of the loons, grebes, fulmars, gannets, cormorants, herons, storks, ducks, geese, and hawks, a total of 67 species, which occur regularly in Sweden.—D. S. Farner.

Techniques for Drawing and Painting Wildlife.—Fredric Sweney. 1959. Reinhold Publishing Corp., New York. 144 pp., many illus. (3 in color). $10.00. —This book (page size 8¼ x 10¼ inches) deals with illustrating birds, fishes, and "animals" (mammals). The novice who does not have access to art school or guidance of a suitable teacher, and who desires instruction via a book using wildlife materials, will find this one to be a helpful introduction to such topics as anatomy, perspective, and step-by-step construction of a picture.—R. S. Palmer.

The Birds of the British Isles. Vol. 8.—D. A. Bannerman. 1959. Oliver and Boyd, Edinburgh. x + 400 pp., 26 col. pls. 63 shillings.—This volume covers 37 species in nine families in this sequence: Phalacrocoracidae, Sulidae, Fregatidae, Procellariidae, Diomedeidae, Podicipedidae, Gaviidae, Columbidae, and Pteroclididae. There are sections by George Waterston, R. M. Lockley, Brian Roberts, L. H. Matthews, K. E. L. Simmons, and accounts of two *Puffinus* species by A. Wetmore. As in earlier volumes, Bannerman attempts to expand (and at times also to correct) existing knowledge of the species he includes. This makes for uneven treatment since, depending on the species, what he chooses to include may pertain to description, distribution, migration, habits, or several such topics. There is a wealth of important new information, which no student of these particular species can afford to ignore. Bannerman's views on nomenclatorial and other matters are presented in a very forthright manner. This reviewer admires Lodge, who was long past his prime as a painter when he illustrated this volume; at times he obviously was painting by formula rather than from first-hand knowledge —a handicap most evident in some of the Tubinare plates.—R. S. Palmer.

RECENT LITERATURE

EDITED BY FRANK McKINNEY

Anatomy and Embryology

Coil, W. H. and D. K. Wetherbee. 1959. Observations on the cloacal gland of the Eurasian quail, *Coturnix coturnix*. Ohio Jour. Sci., **59**: 268–270.—A gland located on the dorsal lip of the cloaca exudes frothy mucoid secretions during sexual activity of the male. A penis-like structure was also identified. This gland may therefore serve as a source of lubrication during copulation.—H. C. S.

Coulombre, A. J. 1957. The role of intraocular pressure in the development of the chick eye. Arch. Ophthal., **57**: 250–253.

Coulombre, A. J. and J. L. Coulombre. 1957. The role of intraocular pressure in the development of the chick eye: III. Ciliary body. Amer. Jour. Ophthal., **44**: 85–92.

Coulombre, A. J. and J. L. Coulombre. 1958. Intestinal development. I. Morphogenesis of the villi and musculature. Jour. Embryol. Exp. Morph., **6**: 403–411.

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Coulombre, A. J. and J. L. Coulombre. 1958. Corneal development. II. Transparency changes during rapid hydration. Amer. Jour. Ophthal., **46**: 276–280.

Coulombre, A. J. and E. S. Crelin. 1958. The role of the developing eye in the morphogenesis of the avian skull. Amer. Jour. Phys. Anth., **16**: 25–37.

Fisher, H. I. 1959. Some functions of the rectrices and their coverts in the landing of pigeons. Wilson Bull., **71**: 267–273.—The effects of removing tail feathers and tail coverts in different patterns on the landing forces of pigeons were measured. These feathers function in "braking" and in supporting the bird's weight.—J. T. T.

Glenny, F. H. 1959. Specific and individual variation in reduction of the clavicles in the parrots. Ohio Jour. Sci., **59**: 321–322.—An examination of 67 genera and 221 species of parrots reveals considerable variation, both intra- and interspecific.—H. C. S.

Lucas, A. M. 1959. A discussion of synonymy in avian and mammalian hematological nomenclature. Amer. Jour. Vet. Res., **20**: 887–897.

Pickman, D. S., A. Ridley, M. Orgel, and H. T. Blumenthal. 1959. Effect of cortisone on growth of chick embryos during early embryogenesis. Endocrin., **64**: 790–794.—Direct inhibition of protein synthesis and growth.—H. C. S.

Behavior

Borror, D. J. 1959. Songs of the chipping sparrow. Ohio Jour. Sci., **59**: 347–356.—This analysis of songs recorded on 58 tapes from five states shows that the "simple trill" is more complex and variable than formerly supposed; no geographic variation was established.—H. C. S.

Burns, P. S. 1957. Rook and Jackdaw roosts around Bishop's Stortford. Bird Study, **4**: 62–71.—The results of five years' study of winter roosting habits. —F. M.

Erard, C. 1959. Observations sur les chants de la Poule d'eau et de la Marouette de Baillon. Nos Oiseaux, **25**: 116–120.—The vocalizations of the Common

Gallinule, *Gallinula chloropus,* and Baillon's Crake, *Porzana pusilla,* in France. —E. E.

FYFE, R. W. 1959. Great Horned Owl distraction display. Blue Jay, **17**: 106.

GOODGE, W. R. 1959. Locomotion and other behavior of the Dipper. Condor, **61**: 4–17.—Includes analysis of movies of movement under water. Wings were used almost exclusively. Brief notes on courtship and feeding.—R. E. P.

GRANT, J. 1959. Wing-clapping display of the Long-eared Owl. Canad. Field-Nat., **73**: 174–175.

GUNTER, G. 1958. Feeding behavior of Brown and White Pelicans on the Gulf Coast of the United States. Proc. La. Acad. Sci., **21**: 34–39.—The Brown Pelican usually dives from the air, but also scoops up fish while sitting; Gulf Coast White Pelicans were never seen to dive.—E. E.

HAMILTON, W. J. III. 1959. Aggressive behavior in migrant Pectoral Sandpipers. Condor, **61**: 161–179.—Detailed study of the territorial behavior of *Erolia melanotos* during fall migration. Individual territories were defended by some but not all of a flock of migrants, and the origin and significance of this are discussed.—R. E. P.

HESS, E. H. 1959. Two conditions limiting critical age for imprinting. Jour. Compar. and Physiol. Psychol., **52**: 515–518.—The maturing motor ability leads to an increase in imprinting behavior while the subsequent development of fear responses leads to a decrease of imprinting. In the fowl these two factors are sufficient to determine the maximum point of the critical period. It remains to be seen whether they will be sufficient in other species.—F. M.

HICKLING, R. A. O. 1957. The social behaviour of Gulls wintering inland. Bird Study, **4**: 181–192.—Describes behavior associated with social feeding, resting, and roosting in a large wintering population of Black-headed Gulls and Herring Gulls.—F. M.

KLOPFER, P. H. 1959. The development of sound-signal preferences in ducks. Wilson Bull., **71**: 262–266.—Incubator-hatched Common Sheldrakes *(Tadorna tadorna),* which were allowed to follow the experimenter while being exposed to sound-signals, developed a preference for these sounds, while ducklings isolated from the experimenter did not do so. The results are compared with those of similar tests with other species of waterfowl.—J. T. T.

LAHRMAN, F. W. 1959. Whooping Crane dance during migration. Blue Jay, **17**: 91–93.

MOORE, N. W. 1957. Territory in dragonflies and birds. Bird Study, **4**: 125–130. —A stimulating comparison dealing mainly with the characteristics and possible functions of territorial behavior in dragonflies.—F. M.

NERO, R. W. 1959. Apparent courtship behaviour of Least Flycatcher. Blue Jay, **17**: 56.

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SABINE, W. S. 1959. The winter society of the Oregon Junco: intolerance, dominance, and the pecking order. Condor, **61**: 110–135.—Analysis of data from marked birds. Believes peck order a result of intolerance rather than dominance and presents evidence to refute concept of an integrating function of peck order.—R. E. P.

SAUNDERS, A. A. 1959. Octaves and kilocycles in bird songs. Wilson Bull., **71**: 280–282.—Mechanical (or electrical) analysis of bird song measures pitch in kilocycles, and can accurately measure time. Analysis by ear uses octaves to indicate pitch.—J. T. T.

SICK, H. 1959. Estudo comparativo das ceremônias pré-nupciais de piprídeos Brasileiros (Pipridae, Aves). Bol. Museu Nacional, n.s. Zool., no. **213**: 1–17.—A comparative account of the prenuptial dances of certain Brazilian manakins. A more elaborate treatment in German is found in Jour. f. Orn., **100**: 269–302, 1959. (In Portuguese; German summary.)—E. E.

SMITH, W. and E. B. HALE. 1959. Modification of social rank in the domestic fowl. Jour. Compar. and Physiol. Psychol., **52**: 373–375.—Conditioning experiments reversed the peck order.—F. M.

SUCHANTKE, A. 1959. Die Paarung beim Flamingo. Orn. Beob., **56**: 94–97.—The copulation of the flamingo *Phoenicopterus ruber roseus*, as observed in the Camargue, with good diagrams. The postures are compared with the rather different posture described and illustrated by Allen for the American form, *P. r. ruber*.—E. E.

TINBERGEN, N. 1957. The functions of territory. Bird Study, **4**: 14–27.—An important discussion that cannot be fully summarized here. "Territory" results from two distinct tendencies, each of which may occur without the other: site attachment and (intraspecific) hostility. The role of hostility as a dispersion mechanism is discussed; a certain balance between attack and escape tendencies is characteristic of each species and is adaptive. Suggestions on promising lines of study are made.—F. M.

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BIOGRAPHY AND HISTORY

BANNERMAN, D. A. 1959. The British contribution to African ornithology. Ibis, **101**: 90–102.—The progress of African ornithology owes its largest debt to British ornithologists, perhaps foremost of these being the author of the present article. The contributions of the early explorers are summarized, and a comprehensive report is presented by regions.—J. W. H.

BARCLAY-SMITH, P. 1959. The British contribution to bird protection. Ibis, **101**: 115–122.—Because of the world-wide extent of the British Empire, we are fortunate that the British have helped lead the way in the protection of wildlife. This has resulted in the preservation of many faunas and has provided an example for other governments to emulate.—J. W. H.

GRANT, C. H. B. 1959. The expedition of the British Ornithologists' Union to New Guinea, 1909–1911. Ibis, **101**: 65–70.—A description of this famous expedition by its last survivor. The author died shortly after writing this article. —J. W. H.

HUXLEY, J. 1959. The British contribution to our knowledge of the living bird. Ibis, **101**: 103–106.—A brief resume of the important part British ornithologists have played in studies of bird behavior and ecology.—J. W. H.

LACK, D. 1959. Some British pioneers in ornithological research, 1859–1939. Ibis, **101**: 71–81.—Discusses those workers and their publications that are judged to have been most important in molding the character of British ornithology. Included are Selous ("Realities of Bird Life"), Howard ("The British Warblers"), W. Eagle Clarke ("Studies in Bird Migration"), Wilson et al. ("The Grouse in Health and Disease"), and Chance ("The Cuckoo's Secret").—J. W. H.

MANSON-BAHR, P. 1959. Recollections of some famous British ornithologists. Ibis, **101**: 53–64.—Biographical sketches of Alfred Newton, Abel Chapman, Henry Eeles Dresser, R. Bowdler Sharpe, William Eagle Clarke, and E. G. B. Meade-Waldo.—J. W. H.

MEINERTZHAGEN, R. 1959. Nineteenth century recollections. Ibis, **101**: 46–52.—Reminiscences concerning British ornithologists and their activities in the last century, written by a man intimately involved in the mainstream of British ornithology almost as much in that century as in the present one.—J. W. H.

MOREAU, R. E. 1959. The centenarian 'Ibis.' Ibis, **101**: 19–38.—The present editor summarizes the remarkable history of the journal. Topic headings include production, editors, editorial policy, size, setting, illustrations, notices and reviews, indexing, cover, contents, and contributors. Included is an interesting table depicting the varying importance of different types of subjects published over the years and a concluding appendix entitled "Buried Treasure" in which humorous passages from the pages of Ibis are gathered together.—J. W. H.

MOUNTFORT, G. 1959. One hundred years of the British Ornithologists' Union. Ibis, **101**: 8–18.—An interesting history of the formation of the Union. Specific subjects dealt with include finance, membership changes, relationship with other societies, meeting places, activities, expeditions, special publications, matters of argument, union awards, the British Ornithologists' Club, and the future of the organization.—J. W. H.

NICHOLSON, E. M. 1959. The British approach to ornithology. Ibis, **101**: 39–45.

ROBERTS, B. 1959. The British contribution to Antarctic ornithology. Ibis, **101**: 107–114.

TENISON, W. P. C. 1959. The Zoological Record (Aves). Ibis, **101**: 123–125. —A brief discussion of the formation, history, and operation of zoology's most comprehensive bibliographic index.—J. W. H.

THOMSON, A. L. 1959. The British contribution to the study of bird migration. Ibis, **101**: 82–89.—The subject is discussed under the following headings: collective recording, intensive observations, bird ringing, experimental work, observations abroad, and theoretical problems (causative factors, mode of operation). —J. W. H.

THORPE, W. H. 1959. Foreword. Ibis, **101**: 1–7.—An introduction to the centennial number of the journal. The evolution of British ornithology during the last 100 years is described. There has been a gradual change in the nature of publications, from species lists and descriptions to the highly technical papers on ecology, migration, and behavior, currently being produced.—J. W. H.

TINBERGEN, N. 1959. Recent British contributions to scientific ornithology. Ibis, **101**: 126–131.—A summary of the impressive forces at work today in Britain to forward the evolution of ornithology.—J. W. H.

Diseases and Parasites

Bassini, E. 1959. Piroplasmosi ed entere-epatite in Gallinacei e Tinamidi. Riser. Zool. Appl. alla Caccia, **3**, no. **30**: 1–16. Lab. Zool. Appl. alla Caccia, Univ. Bologna.—Discussion of avian piroplasmosis in two species of francolins *(Francolinus)* and in the Chukar Partridge *(Alectoris chukar)*, caused by *Egyptianella pullorum;* and of enterohepatitis in the tinamou *Eudromia calopezus*, caused by *Histomonas meleagridis*, the latter acquired in an aviary. The diseased francolins and partridge also showed *Histomonas* in the intestines. (In Italian; English, French and German summaries.)—E. E.

Clapham, P. A. 1957. Helminth parasites in some wild birds. Bird Study, **4**: 193–196.

Jennings, A. R. and **E. J. L. Soulsby.** 1957. Diseases of wild birds, fourth report. Bird Study, **4**: 216–220.

Tendeiro, J. 1958. Malófagos da Guiné Portuguesa. Anais da Junta de Investigaçoes do Ultramar 1955. Estudos de Zoologia, **10**, t. 4, f. 1: 77–113.—Mallophaga of Portuguese Guinea. Includes papers on a parasite of *Pelecanus rufescens*, and on the mallophaga of Galliformes in Portuguese Guinea and Mozambique (including the domestic chicken and turkey). Mention is made of the finding of genera hitherto believed to be exclusive to Galliformes on certain Falconiform species and on a turaco *(Crinifer)*. (In Portuguese; French and English summaries, the French much fuller.)—E. E.

Distribution and Annotated Lists

Beals, E. 1958. Notes on the summer birds of the Apostle Islands (Wisconsin). Passenger Pigeon, **20**: 151–160.

Benson, C. W. 1959. Turturoena iriditorques in the Mwinilunga District, Northern Rhodesia. Ibis, **101**: 240.

Breese, P. L. 1959. Information on Cattle Egret, a bird new to Hawaii. Elepaio, **20**: 33–34.—One hundred and five birds liberated on the main islands to help reduce the number of flies around cattle.—P. H. B.

Davis, J. 1959. The Sierra Madrean element of the avifauna of the Cape District, Baja California. Condor, **61**: 75–84.—Evidence that the avifauna is derived from the same populations as that of Mexico and the southwestern U.S., not from the Pacific coast of Mexico.—R. E. P.

[**Deed, R. F.** *et al.*] 1959. Birds of Rockland County and the Hudson Highlands. 42 pp., map. Price, $1.00. Rockland Audubon Society, West Nyack, N.Y.—A distributional list of an area in New York state, providing information on status, early and late dates, dates of peak abundance, and maximum numbers observed. It documents the recent northward range extension of several species. —E. E.

Frade, F. and **E. A. Bacelar.** 1959. Catálago das aves da Guiné Portuguesa. II Passeres. Estudos de Zoologia, **7**: 1–116. Mem. da Junta de Investig. do Ultramar.—Completes the check-list of birds of Portuguese Guinea.—E. E.

French, N. R. 1959. Distribution and migration of the Black Rosy Finch. Condor, **61**: 18–29.—Distributional and taxonomic data for *Leucosticte tephrocotis atrata* and *L. t. tephrocotis*. Breeding apparently limited by large tundra areas with sufficient moisture.—R. E. P.

FYFE, R. W. 1959. Golden Eagles nesting in Saskatchewan. Blue Jay, **17**: 110–111.

GODFREY, W. E. 1959. Notes on the Great Auk in Nova Scotia. Canad. Field-Nat., **73**: 175.—Based on identification of bone material from a prehistoric shell heap.—R. W. N.

HARRISON, T. and B. E. SMYTHIES. 1959. Some Bornean rarities. Ibis, **101**: 244–245.—On the basis of new and old rediscovered specimen records, eight species of birds are added to the Bornean check-list.—J. W. H.

HOFFMANN, R. S., R. L. HAND, and P. L. WRIGHT. 1959. Recent bird records from western Montana. Condor, **61**: 147–151.

HÖHN, E. O. 1958. Some birds of Jasper Park. Canad. Field-Nat., **72**: 167–168.

HÖHN, E. O. 1959. Birds of the mouth of the Anderson River and Liverpool Bay, Northwest Territories. Canad. Field-Nat., **73**: 93–114.

HOLLOM, P. A. D. 1959. Notes from Jordan, Lebanon, Syria and Antioch. Ibis, **101**: 183–200.—Observations on distribution and field characters made during two short visits to the area lying between southern Turkey and southern Jordan. General accounts of habitat, status, and habits are given for 81 common species, with less-detailed notes on many others.—J. W. H.

HOUSTON, S. 1958. Saskatchewan nesting records of the Cooper's Hawk. Blue Jay, **16**: 153–154.

JOHNSTON, R. F. 1959. The Green Jay *(Cyanocorax yncas)* in Kenedy County, Texas. Texas Jour. Sci., **11**: 320.—Northeasternmost record, some 50 miles from the Rio Grande valley. Subspecific name *luxuosus* is misspelled *"luxosa."* —K. C. P.

JOHNSTON, R. F. and J. W. HARDY. 1959. The Ridgway Whip-poor-will and its associated avifauna in southwestern New Mexico. Condor, **61**: 206–209.

KRAUS, M. 1959. Der Rohrschwirl *(Locustella luscinioides)* in Süddeutschland. Zoologischer Anzeiger [Leipzig], **163**: 142–148.—Analysis of recent range extension of Savi's Warbler, with ecological notes.—K. C. P.

LUMSDEN, H. G. 1959. Mandts' Black Guillemnot breeding on the Hudson Bay coast of Ontario. Canad. Field-Nat., **73**: 54–55.

MACPHERSON, A. H. and I. A. MCLAREN. 1959. Notes on the birds of southern Fox Peninsula, Baffin Island, Northwest Territories. Canad. Field-Nat., **73**: 63–81.

MITCHELL, G. J. 1959. Bird observations at Tahsis Inlet, Vancouver Island, British Columbia. Canad. Field-Nat., **73**: 6-13.

NERO, R. W. 1959. Red-bellied Woodpecker at Regina. Blue Jay, **17**: 95–96.

PAKENHAM, R. H. W. 1959. Field notes on the birds of Zanzibar and Pemba. Ibis, **101**: 245–247.—An annotated list of birds based on records gathered over the period 1946–1956. Notes are mainly on distribution, breeding periods, and migration dates.—J. W. H.

PASSBURG, R. E. 1959. Bird notes from northern Iran. Ibis, **101**: 153–169.—Based on observations over three years, the author discusses habits and migration of 274 species, mainly near Tehran and on the south shore of the Caspian Sea. A map, brief gazetteer, discussion of migration, and an annotated list of birds are presented.—J. W. H.

PAUL, W. A. B. 1959. The birds of Kleena Kleene, Chilcotin District, British Columbia, 1947–58. Canad. Field-Nat., **73**: 83–93.

PAYNTER, R. A. JR. 1959. Birds in the Upper Arctic. *In* Scientific studies at Fletcher's Ice Island, T-3 (1952–1955). vol. 1. Geophysical Research Pap., no.

63: 104. Geophysics Research Directorate. (Available at U.S. Dept. of Commerce, Office of Technical Services, Washington 25, D.C.)—One of a number of papers in a volume containing a variety of articles on geophysics, oceanography, and biology of the Arctic Ocean. (For some additional bird records from Fletcher's Ice Island, see Auk, **75**: 468, 1958.)—E. E.

Quay, T. L. and J. B. Funderburg, Jr. 1959. Expansion of Cattle Egret nesting in North Carolina in 1959. Chat, **23**: 63.

Rabor, D. S., A. C. Alcala, and R. B. Gonzales. 1958. A brief list of land vertebrates of Negros Island. Silliman Jour. [Dumaguete City, Philippines], **5**: 286–300.—Nominal list of 254 birds, including first published records from Negros of two migrants, *Himantopus himantopus leucocephalus* and *Apus affinis subfurcatus*.—K. C. P.

Ruttledge, R. F. 1957. The birds of Inishbofin, Co. Galway. Bird Study, **4**: 71–80.

Sage, B. L. 1959. Some recent observations at Aden. Ibis, **101**: 252–253.—New distributional information on Arabian birds observed at Aden in November 1958 by the author.—J. W. H.

Scott, D. M. 1959. Observations on marine birds off southwestern Nova Scotia. Canad. Field-Nat., **73**: 15–20.

Selander, R. K. and D. R. Giller. 1959. The avifauna of the Barranca De Oblatos, Jalisco, Mexico. Condor, **61**: 210–222.

Sick, H. 1959. A invasão da América Latina pelo pardal, *Passer domesticus* Linnaeus 1758. Com referência especial ao Brasil (Ploceidae, Aves). Bol. Museu Nacional, n.s. Zool., no. **207**: 1–31.—The distribution of the House Sparrow in Latin America, with special reference to Brazil. Introduced in Rio de Janeiro, *P. d. domesticus* is now widely distributed south of Lat. 15° S. The limiting factor northward may be temperature and rainfall. A map of world distribution is included, which appears to bring the North American range south to Honduras, although the text states (correctly) that in middle America it has been recorded only to Mexico. (In Portuguese; German summary.) —E. E.

Smithe, F. B. 1959. Birds of Tikal. A check list. 11 pp. and map. Price, 50 cents. (F. B. Smithe, 645 West 44 St., New York 36, N.Y.)—A useful list of the species known from the area of Tikal, Peten, Guatemala, giving scientific, English, and local names. The map showing location of trails and of the famous Mayan ruins helps visitors to combine archaeology and ornithology. Included are an introduction describing the environment and a good bibliography.—E. E.

Stevens, W. E. and E. O. Höhn. 1958. Some additions to the list of birds of the Mackenzie Delta, N.W.T. Canad. Field-Nat., **72**: 168–170.

Sutter, E., et al. 1959. Verzeichnis der schweizerischen Vogelarten. Orn. Beob., **56**: 69–93.—The species (binomials only) of birds of Switzerland, giving German, French, and Italian Swiss names, with indication of status.—E. E.

Tuck, L. M. 1958. Present distribution and population of the starling in Newfoundland. Canad. Field-Nat., **72**: 139–144.

Tuck, L. M. and L. Lemieux. 1959. The Avifauna of Bylot Island. Dansk Orn. Foren. Tidssk., **53**: 137–154.—An account of the birds observed in 1957 on a Canadian Arctic island north of Baffin Island. Among birds definitely breeding: European Ringed Plover, *Charadrius h. hiaticula, Calidris (Erolia)*

maritima, Larus a. thayeri, Sterna paradisaea. (In English; Danish summary.) —E. E.

Tuck, R. F. 1959. Summer observations of the birds of the Fezzan and Tibesti. Ibis, **101**: 251–252.—Distribution and status of birds in two areas of the Sahara. —J. W. H.

Warner, D. W. and R. W. Dickerman. 1959. The status of *Rallus elegans tenuirostris* in Mexico. Condor, **61**: 49–51.—Specimens considerably extend known range of subspecies.

Ecology and Population

Boyd, H. 1957. Mortality and fertility of the White-fronted Goose. Bird Study, **4**: 80–93.—An analysis of banding returns and field observations at Slimbridge, Gloucestershire, of the Russian-breeding, British-wintering population of *Anser a. albifrons.* Survival rate and seasonal losses of adults and prebreeders have been calculated. The population has not fluctuated greatly in recent years; large-scale breeding failures are thought to occur in most years.—F. M.

Burton, J. F. and D. F. Owen. 1957. The census of heronries 1955–56. Bird Study, **4**: 121–124.

Coulson, J. C. and E. White. 1957. Mortality rates of the Shag estimated by two independent methods. Bird Study, **4**: 166–171.

Coulter, M. W. 1957. Predation by snapping turtles upon aquatic birds in Maine marshes. Jour. Wildl. Mgt., **21**: 17–21.—Twenty-seven per cent of 157 turtles had eaten birds, mostly ducks, grebes, and rails. Predation appeared to be important only where both turtles and ducklings were abundant.—J. P. R.

Cullen, J. M. 1957. Plumage, age and mortality in the Arctic Tern. Bird Study, **4**: 197–207.—Relation between age and plumage was studied in banded birds. Most birds breed first when three years old. In the Farne Island colony some younger males failed to get mates; some of these joined mated pairs and even helped in raising the family. The survival of 102 banded adults showed an annual mortality of 18 per cent.—F. M.

Drinnan, R. E. and M. G. Ridpath. 1957. Counting flocks of roosting birds by photography. Bird Study, **4**: 149–159.

Gibb, J. 1957. Food requirements and other observations on captive tits. Bird Study, **4**: 207–215.—Feeding trials with wild-caught birds showed that the energy requirements of the Great Tit were greatest. The requirements of Blue Tits were slightly less than those of Coal Tits, despite the larger body size of the former. Data are also given on defecation rate.—F. M.

Gompertz, T. 1957. Some observations on the Feral Pigeon in London. Bird Study, **4**: 2–13.—An interesting account of the behavior and ecology of London pigeons. Comparisons are made with wild Rock Doves, the general pattern of behavior being the same in the two forms.—F. M.

Haartman, L. von. 1957. Population changes in the Tufted Duck, *Aythya fuligula* (L.). Soc. Scient. Fennica. Comment. Biol., **16**, no. 5: 1–11.—Counts of nesting birds in Finland between 1935–1955, causes of fluctuations, with a method for statistical analysis of incomplete material (i.e., where survey areas were not all investigated during the same years) by G. Elfving.—E. E.

Haartman, L. von. 1958. The decrease of the Corncrake *(Crex crex).* Soc. Scient. Fennica. Comment. Biol., **18**, no. 2: 1–29.—While there have been fluctuations, in Finland, the Corncrake has had a persistent declining trend since

1905, attributable probably to the increasing use of mowing machinery and the earlier harvesting of hay.—E. E.

JONSELL, B. 1959. The birds in the Källskär—Vattungar archipelago. Variation in the number of breeding birds from about 1890 to 1957. Vår Fågelvärld, **18:** 97–128.—The avifauna of this northern Swedish archipelago consists chiefly of species found in North America. The change in populations of larids is of special interest. (In Swedish; English summary.)—E. E.

LOWE, J. I. 1956. Breeding density and productivity of mourning doves on a county-wide basis in Georgia. Jour. Wildl. Mgt., **20:** 428–433.—Density and production were correlated with call counts on eight 150-acre study areas in 1954. 2.5 pairs per 100 acres produced an average of 2.0 young. The data are expanded to give an estimate for the county.—J. P. R.

SCHORGER, A. W. 1958. Extirpation of a flock of wild turkeys in Adams Co., Wisconsin. Passenger Pigeon, **20:** 170–171.—Account of a 20-year survival period.

SHELDON, W. G. 1956. Annual survival of Massachusetts male woodcocks. Jour. Wildl. Mgt., **20:** 420–427.—Spring trapping from 1950–1955 yielded 128 return records from 86 adult males. These indicate a minimum annual survival of 57 per cent. It is estimated that chicks suffer 69 per cent mortality in their first year.—J. P. R.

SWINK, F. A. 1959. A four-year survey of the ecology of land birds of the Chicago area—Part one [Woodpeckers]. Audubon Bull., no. **111:** 11–13.—Gives number of observations for six species, the kind of tree or other object on which perched, as well as the months.—E. E.

YEAGER, L. E. and H. M. SWOPE. 1956. Waterfowl production during wet and dry years in north-central Colorado. Jour. Wildl. Mgt., **20:** 442–446.—In 1955, during drought, production was 75 per cent less than in 1949, during high water. Over a wider area the decline was only 44 per cent because production in some areas compensated for losses in others.—J. P. R.

GENERAL BIOLOGY

ADAMS, D. A. and T. L. QUAY. 1958. Ecology of the clapper rail in southeastern North Carolina. Jour. Wildl. Mgt., **22:** 149–156.—Breeding biology, seasonal populations, and behavior of *Rallus longirostris* in salt marshes at Southport, N.C., 1955–1956.—J. P. R.

ANDERSON, A. H. and A. ANDERSON. 1959. Life history of the Cactus Wren. Part II: the beginning of nesting. Condor, **61:** 186–205.—Nesting ecology including territorial behavior and the influence of temperature and rainfall on date of first egg.—R. E. P.

BANKS, R. C. 1959. Development of nestling White-crowned Sparrows in central coastal California. Condor, **61:** 96–109.—Description of growth and development based on twice-daily measurements and observations.—R. E. P.

COWLES, G. S. and D. GOODWIN. 1959. Seed digestion by the Fruit-eating Pigeon Treron. Ibis, **101:** 253–254.

FOX, G. A. 1959. A study of early spring nesting of the Horned Lark in the area of Kindersley, Sask. Blue Jay, **17:** 107–109.

FRINGS, H. and M. FRINGS. 1959. Problems of Albatrosses and men on Midway Islands. Elepaio, **20:** 6–9, 14–16, 23–25, 30–33.—Albatrosses were kept successfully in captivity by supplementing food with salt. Length of bill and width

of head were used to distinguish sexes in the field. Types of beak sounds and vocalizations are enumerated and reflections presented concerning minimizing interference of bird with aircraft.—P. H. B.

Frith, H. J. 1959. Breeding of the Mallee Fowl, *Leipoa ocellata* Gould (Megapodiidae). C.S.I.R.O. Wildlife Research, **4:** 31–60.—The breeding season is determined by the availability of natural heat to ferment the organic material in the mounds and achieve the necessary incubation temperature within the mound. Incubation periods varied from 50 to 90 days; the longer periods are believed to reflect lower temperatures. Much data on breeding biology and behavior.—E. E.

Frith, H. J. and R. A. Tilt. 1959. Breeding of the Zebra Finch in the Murrumbidgee Irrigation Area, New South Wales. Emu, **59:** 289–295.—Though in arid areas *Taeniopygia castanotis* breeds after rainfall whenever that occurs, where irrigation provided a permanent water supply breeding occurred throughout the year, except the coldest month, but with a well-defined peak in spring and a lesser one in autumn.—E. E.

Geis, M. B. 1956. Productivity of Canada geese in the Flathead Valley, Montana. Jour. Wildl. Mgt., **20:** 409–419.—Nonbreeding, renesting, nest success, egg success, and gosling mortality were studied in a population of from 800 to 1,077 geese in 1953–1954. 3.16 young/pair were produced in 1953 and 2.32 in 1954.—J. P. R.

Gollop, J. B. 1958. Do Eared Grebes have dump nests? Blue Jay, **16:** 151.—Eggs in two apparent dumps between nests numbered 94 and 101.—R. W. N.

Hanks, E. S. 1959. Cuckoos and the parasitic habit. Emu, **59:** 250–258.—Discusses chiefly the Australian cuckoos.

Hanson, H. C. and C. W. Kossack. 1957. Weight and body fat relationships of mourning doves in Illinois. Jour. Wildl. Mgt., **21:** 169–181.—Average age and frequency of age classes varied in immature doves from different parts of Illinois. Males averaged heavier than females. Rate of gain in body weight and body fat decreased during molt. Great gains of fat were correlated with fertile soil and availability of corn. No consistent relationship appeared between amount of fat, age, and migratory habits.—J. P. R.

Hoffmann, L. et al. 1959. Station Biologique de la Tour de Valat. Quatrième compte rendu d'activité et recueil des travaux 1957: 1–10, over 200 pp.—The report for 1957 of the biological station in the Camargue, France, including reprints of 18 articles by various authors published between 1956–1959, which deal chiefly with Camargue birds. The papers are in French, except for two in English and one in German.—E. E.

Jenkins, D. 1957. The breeding of the Red-legged Partridge. Bird Study, **4:** 97–100.—Records incubation by males and cases of both cock and hen of a pair incubating separate clutches.—F. M.

Kaasa, J. 1959. [On the knowledge of the food of the Black Grouse (*Lyrurus tetrix* (L)) in Norway.] Pap. Norwegian State Game Research, ser. 2. no. **4:** 1–112.—(In Norwegian; English summary table headings, and legends to illustrations.)

Lemieux, L. 1959. The breeding biology of the Greater Snow Goose on Bylot Island, Northwest Territories. Canad. Field-Nat., **73:** 117–128.

Lemieux, L. 1959. Histoire naturelle et aménagement de la grande oie blanche, *Chen hyperborea atlantica*. Naturaliste Canadien, **86**, nos. 8–9: 133–192.—Life history of the Greater Snow Goose—a form with a remarkably restricted range,

breeding on Bylot Island and neighboring Arctic areas and wintering on the Atlantic coast between Delaware Bay and North Carolina. The entire population (estimated at 70,000 in the fall of 1957, but only 47,500 in 1958) spends October and November (nonbreeders arrive in September) and April and most of May on a short strip of the St. Lawrence feeding chiefly on *Scirpus americanus*.—E. E.

Liddy, J. 1960. Notes on the Black Kite in north-west Queensland. Emu, **59**: 268–274.—Food and behavior of *Milvus migrans*.

Marchant, S. 1959. The breeding season in S.W. Ecuador. Ibis, **101**: 137–152. —Discusses general aspects of the breeding season of birds of the Santa Elena Peninsula, Ecuador, based on data gathered from 1954 to 1958. Deals with broad aspects of the environment, breeding incidence, specific breeding periods, annual fluctuations in breeding, and a comparison with breeding in the Galapagos Islands (same near-equatorial latitude, similar climate).—J. W. H.

McClure, H. E., M. Yoshii, Y. Okada, and W. F. Scherer. 1959. A method for determining age of nestling herons in Japan. Condor, **61**: 30–37.—Measurements of upper mandible, tarsus, and third primary of known-aged young were variable but allowed better aging than gross observation of size and development.—R. E. P.

Newton, R. 1959. Notes on the two species of Foudia in Mauritius. Ibis, **101**: 240–243.—Discussion of occurrence, habits, and habitat of *Foudia madagascariensis* and *rubra*. Contains historical notes.—J. W. H.

Owen, D. F. 1959. The breeding season and clutch-size of the Rook *Corvus frugilegus*. Ibis, **101**: 235–239.—Data were gathered in the Oxford district in 1952–1957. Discussion is of breeding season, including egg laying, weekly air temperature, clutch-size, nesting success, survival of nestlings in relation to brood size, and annual differences in survival. Variations in breeding season near Oxford could be correlated with mean air temperatures in the period before egg laying. In five of six years, broods starting at five raised more young than those starting at four.—J. W. H.

Pettingill, O. S., Jr. 1959. King Eiders mated with Common Eiders in Iceland. Wilson Bull., **71**: 205–207.—Male King Eiders *(Somateria spectabilis)* mated with female Common Eiders *(S. mollissima)*—a colored photograph of such a pair is included—are a rare but regular occurrence in Iceland, where *S. mollissima* is the common species. The reciprocal mating has not been observed. —J. T. T.

Royama, T. 1959. A device of an auto-cinematic food-recorder. Tori, **15**: 172–176.—A description, in English, with diagrams, of a device for recording the food brought to nestlings.—E. E.

Skutch, A. F. 1959. Life history of the Blue Ground Dove. Condor, **61**: 65–74, with color plate by Don Eckelberry.—Includes observations on the role of the sexes through the breeding cycle in the sexually dimorphic *Claravis pretiosa*. —R. E. P.

Stabler, R. M. 1959. Nesting of the Blue Grosbeak in Colorado. Condor, **61**: 46–48.

Steel, P. E., P. D. Dalke, and E. G. Bizeau. 1957. Canada goose production at Gray's Lake, Idaho, 1949–1951. Jour. Wildl. Mgt., **21**: 38–42.—Data from 380 nests on time of nesting, nest sites, nest and egg success, clutch-size and gosling production.—J. P. R.

SUTTON, G. M. 1959. The nesting fringillids of the Edwin S. George Reserve, southeastern Michigan. (Pt. 3). Jack-Pine Warbler, **37:** 77–101.—Notes on general behavior, plumages, molt, and nesting of the Cardinal, Rose-breasted Grosbeak, and Indigo Bunting.—E. E.

SWIFT, J. J. 1959. Le Guépier d'Europe *Merops apiaster* L. en Camargue. Alauda, **27:** 97–143.—Life-history data on the European Bee-eater in the Camargue. This species has been extending its range in western Europe. (In French; English summary.)—E. E.

WESTERSKOV, K. 1959. The nesting habitat of the Royal Albatross on Campbell Island. Proc. N.Z. Ecol. Soc., no. **6:** 16–20.—*Diomedea e. epomophora,* the largest of sea birds, breeds on Campbell Island, where there is almost permanent strong wind. On rare calm days the birds may be grounded. Nests are usually on the leeward side of ridges in tussock, and are used for years. Individuals nest only in alternate years.—E. E.

WINGE, A. 1959. [The Mute Swan *(Cygnus olor)* in Scania, southern Sweden, in 1957.] Vår Fågelvärld, **18:** 1–11.—The Mute Swan breeds not only in the brackish water creeks of the Baltic but on the saline southwest coast using wrackbeds as nests. (In Swedish; English summary.)—E. E.

GENETICS AND EVOLUTION

BOWERS, D. E. 1959. A study of variation in feather pigments of the Wren-tit. Condor, **61:** 38–45.—Microscopic measurements of melanin aggregations in two races of *Chamaea fasciata* suggest relatively simple genetic differences.—R. E. P.

HAILMAN, J. P. 1959. Why is the male Wood Duck strikingly colorful? Amer. Naturalist, **93:** 383–384.—The theoretical answer to this question supplied by Dilger and Johnsgard (Wilson Bull., **71**, 1959: 46–53) is amplified. Hailman suggests that the slow and late visual learning of young *Aix* (as shown by Klopfer, Ecology, **40**, 1959: 90–102) is compensated for by the exceptionally striking plumage of the male, allowing easier recognition by the female, thus reducing the likelihood of hybridization.—K. C. P.

IRWIN, M. R. 1959. Interrelationships of genetic characters which differentiate species of doves *(Streptopelia).* Syst. Zool., **8:** 48–57.—Information derived from laboratory crosses and backcrosses of *S. chinensis, risoria,* and *senegalensis.* Size differences appear to be based on multiple genes with individually small effects. Comparisons of erythrocyte antigens indicate that pairs of species share certain antigenic characters, but may have as many as 10 species-specific unit antigenic characters. There are less genes for antigenic characters distinguishing *chinensis* and *senegalensis* than distinguish either from *risoria,* indicating a relatively closer taxonomic relationship of the first two species.—K. C. P.

MUNKÁCSI, F. 1959. Iso-serological studies in ducks. Acta Biologica, **10:** 101–105. Hungarian Academy of Sciences, Budapest.—Crossing of Muscovy *(Cairina moschata)* with two breeds of domestic ducks, Khaki Campbell and Pekin (both *Anas platyrhynchos*), resulted in some fertile hybrids where the drake was Campbell and the duck Muscovy, but not from the reciprocal cross, nor from the cross between Muscovy and Pekin. Tests were made to determine whether hybrid sterility was the result of blood-group factors.—E. E.

O'DONALD, P. and P. E. DAVIS. 1959. The genetics of the colour phases of the Arctic Skua. Heredity, **13:** 481–486.—Three color phases of *Stercorarius para-*

siticus are described. On the basis of the numbers of the different phases at Fair Isle since 1951, it is suggested that there is a stationary cline.—F. M.

Sibley, C. G. and L. L. Short, Jr. Hybridization in some Indian Bulbuls Pycnonotus cafer X P. leucogenys. Ibis, **101**: 177–182.—*P. leucogenys* and *leucotis* are probably conspecific. The ranges of *cafer* and *leucogenys* overlap; the area of overlap (in central and northern India) is a zone of secondary contact. Local hybridization only, of the two forms, indicates evolution has proceeded almost to the point of complete genetic isolation. Hybrids rarely occur except where one species is uncommon. Hybrid incidence is probably decreasing, the isolating mechanism being enforced.—J. W. H.

Udagawa, T. 1958. Karyogram studies of birds. X. The chromosome(s) of some species of the Passeres and Limicolae. Annot. Zool. Japon., **31**: 43–48.—*Garrulus glandarius* 82 chromosomes, *Parus varius* 82, *Regulus regulus* 82, *Saxicola torquatus* 86, *Rostratula benghalensis* 84.—P. H. B.

Management and Conservation

Agee, C. P. 1957. The fall shuffle in central Missouri bob-whites. Jour. Wildl. Mgt., **21**: 329–335.—Fall movements and social changes in a marked population of wild quail including a discussion of covey formation.—J. P. R.

Aldrich, J. W., A. J. Duvall, and A. D. Geis. 1958. Racial determination of origin of mourning doves in hunters' bags. Jour. Wildl. Mgt., **22**: 71–75.—Mourning doves in hunters' bags in Texas and Georgia were separated into eastern or western races or an intermediate between them by examination of wings.—J. P. R.

Carney, S. M. and G. A. Petrides. 1957. Analysis of variance among participants in pheasant cock-crowing censuses. Jour. Wildl. Mgt., **21**: 392–397.—Variation among experienced counters was less than among inexperienced, and greater for both groups when calls of more than one species were counted. —J. P. R.

Dorney, R. S. and F. V. Holzer. 1957. Spring aging methods for ruffed grouse cocks. Jour. Wildl. Mgt., **21**: 268–274.—Spring-trapped cocks were classified as juveniles or adults with high accuracy by using six different age criteria. —J. P. R.

Dorney, R. S., D. R. Thompson, J. B. Hale, and R. F. Wendt. 1958. An evaluation of ruffed grouse drumming counts. Jour. Wildl. Mgt., **22**: 35–40.—Drumming counts accurately reflected the number of territorial males on two study areas in Wisconsin. There was also close correlation between drumming counts and winter flush counts.—J. P. R.

Durant, A. J. 1956. Impaction and pressure necrosis in Canada geese due to eating dry hulled soybeans. Jour. Wildl. Mgt., **20**: 399–404.—Geese at Swan Lake Refuge in Missouri were fatally injured when they gorged on soybeans, which swelled in the esophagus. Injuries are described and management recommendations presented.—J. P. R.

Fant, R. J. 1957. Criteria for aging pheasant embryos. Jour. Wildl. Mgt., **21**: 324–328.—Includes a discussion of embryonic mortality.—J. P. R.

Hammond, M. C. and G. E. Mann. 1956. Waterfowl nesting islands. Jour. Wildl. Mgt., **20**: 345–352.—The utilization of man-made islands by nesting ducks and geese on Lower Souris Refuge in North Dakota is described. Nesting

density, species involved, behavior of pairs, methods and costs of construction are discussed.—J. P. R.

HAUGEN, A. O. 1957. Distinguishing juvenile from adult bobwhite quail. Jour. Wildl. Mgt., **21**: 29–32.—The 7th upper primary covert is useful in aging the 2-3 per cent of quail wings not separable by other plumage characters.—J. P. R.

HOUSTON, S. 1958. The diving duck crisis. Blue Jay, **16**: 163–164.—General report of declining populations.—R. W. N.

JOHNSGARD, P. A. and I. O. BUSS. 1956. Waterfowl sex ratios during spring in Washington state and their interpretation. Jour. Wildl. Mgt., **20**: 384–388.—15,000 ducks of 17 species were counted in 1954. Factors affecting the counts are discussed, and a comparison is made with other published data.—J. P. R.

JUMBER, J. F., H. O. HARTLEY, E. L. KOZICKY, and A. M. JOHNSON. 1957. A technique for sampling mourning dove populations. Jour. Wildl. Mgt., **21**: 226–229.—A technique for estimating production by counting doves fledged from nests in sample blocks of trees in Lewis, Iowa. Dove production for 1938–1940 is compared with that for 1955.—J. P. R.

KORSCHGEN, L. J. 1958. Food habits of the mourning dove in Missouri. Jour. Wildl. Mgt., **22**: 9–16.—Crop contents of 2,000 doves collected April–October, 1951–1953, are reported. Two thirds of the food was from agricultural crops. Major changes in food habits between different months and years were noted. —J. P. R.

LABISKY, R. F. 1957. Relation of hay harvesting to duck nesting under a refuge-permittee system. Jour. Wildl. Mgt., **21**: 194–200.—Discusses the destruction of duck nests by haying operations on Horicon National Wildlife Refuge in Wisconsin. Management recommendations are included.—J. P. R.

LARSEN, J. A. and J. F. LAHEY. 1958. Influence of weather upon a ruffed grouse population. Jour. Wildl. Mgt., **22**: 63–70.—Statistical techniques show an association between population variability and annual changes in the distribution pattern of maximum temperature. Warm days in spring and summer are associated with a high population the following April and warm days in winter with a low population.—J. P. R.

LOCKIE, J. D. and D. STEPHEN. 1959. Eagles, lambs and land management on Lewis. Jour. Animal Ecol., **28**: 43–50.—Investigation of a complaint of lamb killing by Golden Eagles on the island of Lewis. Rabbit was the main food; lambs were killed occasionally. Overstocking of habitat with sheep has caused considerable winter and spring losses. This carrion is thought to be maintaining an artificially high density of eagles. Improved land use rather than shooting is suggested.—F. M.

MCCABE, R. A. and G. A. LEPAGE. 1958. Identifying progeny from pheasant hens given radioactive calcium (Ca^{45}). Jour. Wildl. Mgt., **22**: 134–141.—Radioactive Ca^{45} shows up in the eggs and subsequently in the bones of young in the fall when implanted subcutaneously as a pellet of $Ca_3(PO_4)_2$ in spring-released pheasants.—J. P. R.

NELSON, D. J. 1957. Some aspects of dove hunting in Georgia. Jour. Wildl. Mgt., **21**: 58–61.—Information on the dove kill from hunter bag checks, 1949–1953, including hunter success, crippling loss, and dove movements.—J. P. R.

ROSENE, W., JR. 1957. A summer whistling cock count of bobwhite quail as an index to wintering populations. Jour. Wildl. Mgt., **21**: 153–158.—In Alabama and South Carolina during four years the number of winter coveys could be predicted from summer whistle counts. Areas 500–1,700 acres in size, totaling

at least 12,000 acres within a similar environment, were necessary for reliable results.—J. P. R.

Schultz, V. and R. D. McDowell. 1957. Some comments on a wild turkey brood study. Jour. Wildl. Mgt., **21**: 85–89.—The usefulness of brood data in providing information on the status of turkeys is statistically analyzed.—J. P. R.

Warbach, O. 1958. Bird populations in relation to changes in land use. Jour. Wildl. Mgt., **22**: 23–28.—Modern conservation farming was applied to a 210-acre partly abandoned farm on the Patuxent Research Refuge in Maryland from 1947 to 1950. The number of nesting species declined 10 per cent, and the number of nesting pairs declined 40 per cent. Brushland species suffered most. The change is attributed more to the loss of thickets and second growth to cultivation than to the kind of farming practiced.—J. P. R.

Migration and Orientation

Bard, F. G. 1959. Annual report of Whooping Cranes in Saskatchewan, 1958. Blue Jay, **17**: 9–11.

Bourne, W. R. P. 1959. Notes on autumn migration in the Middle East. Ibis, **101**: 170–176.—Evidence is given for passage of small land birds and water birds directly across the Arabian desert in migration from the Palaearctic to the Ethiopian region (avoiding the Mediterranean and Sahara). Local movements of larks and sand-grouse are discussed, and the arrival of winter visitors from the north described.—J. W. H.

Boyer, G. F. 1959. Hand-reared Mallard releases in the Maritime Provinces. Canad. Field-Nat., **73**: 1–5.—Mallards introduced into this area of the Black Duck range "were in the process of being absorbed into the vastly larger Black Duck population."—R. W. N.

Graber, R. R. and W. W. Cochran. 1959. An audio technique for the study of nocturnal migration of birds. Wilson Bull., **71**: 220–236.—The equipment consisted of a parabolic reflector, microphone, amplifier, and tape recorder by which the calls of night migrants were recorded. The construction, modification, and use of the equipment are described. It successfully recorded identifiable calls and allowed measurements of flight density variations.—J. T. T.

Groh, H. 1958. Blue Jay flyway near Ottawa. Canad. Field-Nat., **72**: 167.

Harper, W. G. 1959. Roosting movements of birds and migration departures from roosts as seen by radar. Ibis, **101**: 201–208.—Observations were made with 10–cm. plan-position and range-height radars at a station 30 miles northwest of London. This is an area particularly subject to wintering movements of flocks of birds from north-central Europe. Echoes attributable to roosting movements of large flocks and to departures from roosts on migratory flights are illustrated. Most striking displays are received from Starlings. There is evidence of more rapid break-up of flocks on migration at night than by day. —J. W. H.

Helms, C. W. 1959. Song and Tree Sparrow weight and fat before and after a night of migration. Wilson Bull., **71**: 244–253.—Individuals of Song Sparrows *(Melospiza melodia)* and Tree Sparrows *(Spizella arborea)* before a migratory flight have significantly higher body weight and fat than do postmigratory individuals. Two patterns of weight and fat variation in emberizines are described.—J. T. T.

HORVÁTH, L. 1959. Observations on the potamic and pelagic migrations of birds along the Danube and in the Levant. Acta Zool. Acad. Sci. Hungar., **5**: 353–366.

LACK, D. 1959. Migration across the North Sea studied by radar Part 1. Survey through the Year. Ibis, **101**: 209–234.—A thorough treatment of migration across the North Sea off Norfolk using radar records for three years. Unknown until this study were large eastward emigrations in spring, arrivals southwest, presumably from Scandinavia, in late fall, and possible redetermined movements eastward after drifted arrivals. Characteristic migratory patterns of different kinds of birds are discussed.—J. W. H.

MEDEIROS, J. S. 1958. Present status of migratory waterfowl in Hawaii. Jour. Wildl. Mgt., **22**: 109–117.—The past and current status of waterfowl, especially ducks, in Hawaii, and results of a banding study of pintails, 1949–1955. Data on migration between Hawaii and continental N. America are presented.—J. P. R.

MOREAU, R. E. 1959. Problèmes de la migration au Maroc. Alauda, **27**: 81–96. —Problems of migration in Morocco. (In French; English summary.)

NISBET, I. C. T. 1957. Wader migration at Cambridge sewage farm. Bird Study, **4**: 131–148.—An important analysis of records of 24 migrant shorebird species based on counts for six years and less-detailed counts over 30 years. A few species show a double peak of abundance, both in spring and fall; most show a single peak in spring, double peak in fall (adults early, young later). The duration of spring migration is correlated with the extent of the breeding range. The date of peak migration in spring is correlated with the latitude (longitude in arctic birds) of the breeding range, and with size (wing length).—F. M.

NISBET, I. C. T. 1959. Calculation of flight directions of birds observed crossing the face of the moon. Wilson Bull., **71**: 237–243.—Instructions and tables are given from which observers without mathematical training can calculate flight directions and approximate densities of migrating birds observed flying across the face of the moon.—J. T. T.

OEMING, A. F. 1958. Recoveries in Alberta of banded Snowy Owls. Canad. Field-Nat., **72**: 171–172.

PENOT, J. 1959. Aperçu sur les migrations du Canard Colvert *(Anas platyrhynchos)* d'après les données françaises du baguage recueillies jusqu'en 1958. L'Oiseau, **29**: 51–62.—French banding records of the Mallard.—E. E.

PERDECK, A. C., H. KLOMP, *et al.* 1959. [Annual report of the Vogeltrekstation, Netherlands for 1958.] Limosa, **32**: 87–107.—Includes reports on orientation experiments with teal and starlings and interesting observations on the direction of visible migration of chaffinches in autumn. (In Dutch; English summary.) —E. E.

RAYNOR, G. S. 1959. A meteorological analysis of the 1958 Island Beach netting data. Ebba News, **22**: 73–81.—September mist-netting correlations with weather at Island Beach, New Jersey.—E. E.

ROSENBERG, N. T. 1959. [Observations of the spring migration at Gilleleje, North Zealand, Denmark.] Dansk Orn. Foren. Tidssk., **53**: 121–136.—Numbers are greatest along the north coast when the wind is southeasterly; this is attributed to drift. (In Danish; English summary.)—E. E.

SAUNDERS, A. A. 1959. Forty years of spring migration in southern Connecticut. Wilson Bull., **71**: 208–219.—Migration data are summarized for summer residents, winter visitors, and transients in the area. The arrival dates for four selected years are compared with the average to illustrate conspicuous differences between years.—J. T. T.

SAUER, F. and E. SAUER. 1959. Nächtliche Zugorientierung europäischer Vögel in Südwestafrica. Vogelwarte, **20**: 4–31.—Various European passerines normally wintering in South West Africa were transported to that country south of the Equator just before the fall migration. Placed in a rotable cage, open to the sky during the period of migration, these birds faced to the south in the fall and the north in the spring, when the nights were clear, but the period of activity in the fall was shortened. This is attributed to seeing the stars of the winter quarters. Moonlight and sheet lightning caused positive phototactic deviations, partial clouds caused correction movements, and heavy overcast general disorientation. (In German; English summary.)—E. E.

SICK, H. 1959. Vom Vogelzug vor der afrikanischen NW-Küste. Vogelwarte, **20**: 31–32.—Notes on migrant birds seen at sea off the coast of northwest Africa.—E. E.

SOUTHERN, W. E. 1959. Homing of Purple Martins. Wilson Bull., **71**: 254–261. —All of 16 *Progne subis* released at distances between 1.75 and 234 miles from their nests returned to their nests, one covering 234 miles in 8.58 hours of nocturnal flight.—J. T. T.

STOLT, B-O. 1959. [The autumn migration at Norra Kvarngärdet Uppsala, and its relation to the weather conditions.] Vår Fågelvärld, **18**: 12–33.—Nocturnal migration often took place in the night of a temperature fall, the diurnal migration on the following morning. A rise in temperature was an inhibiting factor. Fall in temperature generally occurs in Scandinavia when a cyclone passes towards the east, followed by an air stream from the north. (In Swedish; English summary.)—E. E.

PHYSIOLOGY

ADLER, H. E. and J. I. DALLAND. 1959. Spectral thresholds in the Starling *(Sturnus vulgaris)*. Jour. Compar. and Physiol. Psychol., **52**: 438–445.

ELTON, R. L., I. G. ZARROW, and M. X. ZARROW. 1959. Depletion of adrenal ascorbic acid and cholesterol: a comparative study. Endocrin., **65**: 152–157.—Exposure to severe cold and injections of ACTH failed to produce depression of adrenal ascorbic acid in chickens.—H. C. S.

HOWELL, T. R. and G. A. BARTHOLOMEW. 1959. Further experiments on torpidity in the Poor-will. Condor, **61**: 180–185.—Body temperature and oxygen consumption of a captive Poor-will induced to undergo repeated torpidity by low ambient temperatures.—R. E. P.

PEREK, M., B. ECKSTEIN, and Z. ESHKOL. 1959. The effect of ACTH on adrenal ascorbic acid in laying hens. Endocrin., **64**: 831–832.—Whereas ascorbic acid was depleted 57 per cent in one-year-old laying hens, no effect could be elicited in three-month-old pullets.—H. C. S.

RALPH, C. L. and R. M. FRAPS. 1959. Effect of hypothalamic lesions on progesterone-induced ovulation in the hen. Endocrin., **65**: 819–824.—Preoptic hypothalamus is undoubtedly concerned with gonadotrophin liberation following progesterone administration.—H. C. S.

RAYMOND, A. M. 1958. Responses to electrical stimulation of the cerebellum of unanesthetized birds. Jour. Comp. Neur., **110**: 299–320.

SHELLABARGER, C. J. 1959. Biological potency of 3,3', 5' triiodothyronine in birds. Endocrin., **65**: 503–504.

SOLOMON, J. and R. O. GREEP. 1959. The growth hormone content of several vertebrate pituitaries. Endocrin., **65**: 334–335.—Includes chicken, which had only a small potency for the test used.—H. C. S.

TAXONOMY AND PALAEONTOLOGY

CLANCEY, P. A. and J. G. WILLIAMS. 1959. On the unknown female dress and specific relationships of *Ploceus golandi* (Clarke). Ibis, **101**: 247–248.—The previously unique type was collected in 1955. The species has recently been discovered in numbers in Kenya. This paper contains the first description of the female plumage, based on the first female specimen. It is concluded that though females of *golandi* and *weynsi* are much alike, the two forms are distinct species.—J. W. H.

DOWNS, T., H. HOWARD, T. CLEMENTS, and G. A. SMITH. 1959. Quaternary animals from Schuiling Cave in the Mojave Desert, California. L.A. Co. Mus. Contrib. Sci. No. **29**, 21 pp.—Fifteen species of birds are included in the fauna represented by skeletal remains. Included are *Gymnogyps amplus* Miller and a large form of *Bubo virginianus*. The total faunal content and the geology of the cave suggest late Pleistocene age for the cave fauna.—H. H.

HOWARD, H. 1958. Miocene sulids of southern California. L.A. Co. Mus. Contrib. Sci. No. **25**, 15 pp.—Three Miocene localities in Los Angeles County (two newly recorded) yielded fossil sulids. *Sula willetti* Miller is tentatively recorded; *Sula pohli* is described as a new species, and *Sula stocktoni* Miller is recorded under the newly described genus, *Paleosula*.—H. H.

HUSAIN, K. Z. 1959. Taxonomic status of the Burmese Slaty-headed Parakeet. Ibis, **101**: 249–250.—Evidence is presented indicating the specific distinctness of *Psittacula himalayana* (Lesson 1832) and *P. finschii* (Hume 1874).—J. W. H.

LINSLEY, E. G. and R. L. USINGER. 1959. Linnaeus and the development of the International Code of Zoological Nomenclature. Syst. Zool., **8**: 39–47.—A brief review of the history of codes of zoological nomenclature, culminating in the International Code. Post-1901 changes in the latter are summarized, and major remaining problems (particularly "conservation" of names) critically discussed.—K. C. P.

MAINARDI, D. 1959. Un nuovo metodo di immunologia comparata a scopo sistematico basato sulla sommazione delgi antigeni comuni. Istituto Lombardo Accad. di Sci. e Lettere (Milan), **93**: 91–96.—A new immunological method confirms that the Domestic Goose *(Anser anser)* is distantly related to the Mallard *(Anas platyrhynchos)* and still more distantly to the Muscovy *(Cairina moschata)*.—F. M.

MILLER, L. and R. I. BOWMAN. 1958. Further bird remains from the San Diego Pliocene. L.A. Co. Mus. Contrib. Sci. No. **20**, 15 pp.—Of the 10 species discussed, three are new to science: *Sula humeralis, Colymbus subparvus,* and *Ptychoramphus tenuis*.—H. H.

PARKES, K. C. 1959. Subspecific identity of introduced Tree Sparrows *Passer montanus* in the Philippine Islands. Ibis, **101**: 243–244.—*P. montanus manillensis* Hachisuka must be placed in synonymy with *P. m. saturatus* rather than with *malaccensis*. Vaurie's synonymization of *bokotoensis* with *saturatus* was in error. The former now becomes a synonym of *iubilaeus*. It is concluded that *P. montanus* has been introduced into the Philippines from two sources: in

Luzon, *saturatus* from the north (probably Japan or Formosa); and in Cebu, *malaccensis* from the Malay Peninsula, perhaps Singapore. Conclusions are based on plumage and bill-size considerations.—J. W. H.

RAND, A. L. 1959. Tarsal scutellation of song birds as a taxonomic character. Wilson Bull., **71**: *274–277*.—The character proved too variable to be of great use in classification.—J. T. T.

RAND, A. L. 1960. A new species of babbling thrush from the Philippines. Fieldiana, Zool., **39**, no. 33: *377–378*.—Description of a new species of babbler, *Napothera rabori*, from northern Luzon. The genus was not previously known from the Philippines.—M. A. T.

SIBLEY, C. G. and P. A. JOHNSGARD. 1959. Variability in the electrophoretic patterns of avian serum proteins. Condor, **61**: 85–95.—Profiles of several species are given, and the sources of the great intra-specific variation are examined. Egg-white protein is more satisfactory for taxonomic purposes.—R. E. P.

STEARN, W. T. 1959. The background of Linnaeus's contributions to the nomenclature and methods of systematic biology. Syst. Zool., **8**: 4–22.—A valuable survey of the historical development of Linnaeus' philosophy of classification. Ironically, Linnaeus, revered as the father of binomial nomenclature, considered the diagnostic polynomials in his works as more important than the binomials. —K. C. P.

STRESEMANN, E. 1959. Die Gliederung der Schlangenadler-Gattung *Spilornis*. Vierteljahrsshr. Naturforsch. Ges. Zürich, **104**: *208–213*. Festschrift H. Steiner.—On the taxonomy of the Snake-Eagle genus. Stresemann disagrees with Meise's "oversimplification," which reduced the genus to three polytypic species. "Since the term 'intergradation' was stricken from the subspecies definition, . . . trinomial nomenclature has followed a dangerous course. . . . When too broadly applied, trinomial nomenclature becomes not a mirror of nature, but a caricature." Examples are given of various birds of prey that seemed to be allopatric subspecies, until sympatry was proved.—E. E.

TODD, W. E. C. 1958. Newfoundland race of the Gray-cheeked Thrush. Canad. Field-Nat., **72**: 159–161.

VAURIE, C. 1959. Systematic notes on Palearctic birds. No. 36. Picidae: The genera *Dendrocopos* (Part 2) and *Picoïdes*. Amer. Mus. Novitates, **1951**: 24 pp.—*D. hyperythrus* has four valid races as listed by Peters, but his outline of the range of *D. h. subrufinus* was erroneous, as he was unaware that this race is migratory. *Picus incognitus* Scully, 1879, is an older name for *D. auriceps conoveri* Rand and Fleming, 1956. Of 28 described races of *D. minor*, 13 at most are considered valid. Of the 15 currently accepted races of *D. canicapillus*, only the three Palearctic ones are discussed. *Dryobates obscurior* Rothschild, known only from the type, is a normal juvenile of *D. c. omissus*, not an aberration as claimed by other authors. Nine races of *D. kizuki* are admitted, and, tentatively, eight Palearctic races of *P. tridactylus*.—K. C. P.

VAURIE, C. 1959. Systematic notes on Palearctic birds. No. 37. Picidae: The subfamilies Jynginae and Picumninae. Amer. Mus. Novitates, **1963**: 16 pp.—In addition to the five races of *Jynx torquilla* recognized by Peters, Vaurie admits *sarudnyi* Loudon from Transcaspia, and describes *himalayana* from Kashmir as new. Three races of *Picumnus innominatus* reach the Palearctic. —K. C. P.

VAURIE, C. 1959. Systematic notes on Palearctic birds. No. 38. Alcedinidae, Meropidae, Upupidae, and Apodidae. Amer. Mus. Novitates, **1971**: 25 pp.—Three races of *Ceryle rudis* are admitted. Although only peripherally Palearctic, *Merops albicollis* is carefully reviewed; there are no valid races. The genus *Aerops* is considered inseparable from *Merops*. The five Palearctic races of *M. orientalis* are reviewed. There are four valid Palearctic races of *Upupa epops;* its relationship to *U. africana* is discussed. Swifts reviewed are *Apus pallidus, pacificus,* and *melba; A. acuticaudatus* is a good species and not a race of *pacificus*.—K. C. P.

WEBSTER, D. J. 1959. A revision of the Botteri Sparrow. Condor **61**: 136–146. —Based on a study of most of the skins in the U.S. (398 specimens examined). —R. E. P.

WEBSTER, J. D. 1959. The taxonomy of the Robin in Mexico. Wilson Bull., **71**: 278–280.—Notes on *Turdus migratorius propinquus* and *T. m. phillipsi.*

WILLS, R. G. 1958. The dowitcher problem. Passenger Pigeon, **20**: 95–105.—A critical examination of available Wisconsin specimens.

NOTES AND NEWS

The American Ornithologists' Union will meet in 1960 at Ann Arbor, Michigan, with The University of Michigan as the host organization. The meeting is jointly sponsored by the Detroit Audubon Society, the Michigan Audubon Society, the Museum and the Department of Zoology of Michigan State University, and the Museum of Zoology of The University of Michigan. The scientific sessions will be held Wednesday, Thursday, and Friday, 24-26 August, at the Horace H. Rackham School of Graduate Studies on The University of Michigan campus. The business sessions will be held on Tuesday, 23 August, in the same building. Field trips are planned for Saturday, 27 August. The Annual Banquet will be held in the ballroom of the Michigan Union on Friday evening, 26 August.

Applications for a position on the program should be submitted not later than 1 July. A formal "call for papers" will be circulated well before the deadline.

Adults and children over the age of 14 attending the meeting may be housed in the East Quadrangle on the campus. A "package price" of $25.00, which includes lodging for the nights of 23 August through 27 August and meals from breakfast on 24 August through breakfast on 27 August (with the exception of dinner on 26 August—the night of the banquet), will be charged. Members arriving 22 August can be lodged that night for an additional $3.00. In addition, there are several motels on the outskirts of Ann Arbor and a few rooms available in hotels in the campus area. Mr. Norman L. Ford, Museum of Zoology, The University of Michigan, Ann Arbor, is in charge of accommodations.

It will be a pleasure to welcome members and their families and guests to the first meeting of the Union in Ann Arbor.

Notice is again given of the availability of $600 from the Josselyn Van Tyne Memorial Fund for aid in ornithological research.

Any student of birds who has a special need for equipment, travel, assistance, or materials to further his research is invited to submit an application (10 duplicate copies) for a portion or all of the money available. This application should give a full description of the proposed research, the type of help that is required, when the money should be made available, the background and training of the applicant, and other pertinent information. The applications will be evaluated and rated by the Research Committee of the A.O.U. to determine how the funds will be allotted.

All applications for grants must be in the hands of the chairman not later than 1 June 1960.—S. Charles Kendeigh, *Chairman, Vivarium Building, University of Illinois, Wright and Healey Sts., Champaign, Illinois.*

CORRESPONDENCE

Juvenile Cannibalism in Short-eared Owls

It is evident from Mr. Armstrong's letter (Auk, 76 (4): 560, 1959) that he considers I have been too ready in assuming that the five owlets that mysteriously disappeared from the two nests of the Short-eared Owls *(Asio flammeus)* referred to in my paper (Auk, 76 (2): 222–226, 1959) had been devoured by their nestmates. Admittedly my assumption that they had been the victims of cannibalism was based on circumstantial evidence, but in my opinion that evidence was so overwhelmingly convincing that there could be virtually no doubt that their disappearance had been due to that cause. If they had "crawled out of the nest to secrete themselves some distance away," as Mr. Armstrong seems to suggest, surely it would have been the oldest, and not the youngest, members of the brood that would have done so on being disturbed by a human being? In any case, one or two of the missing owlets were at the time of their disappearance so recently hatched, and therefore so feeble, that it would have been physically impossible for them to have left their nests unaided.

Incidentally, since the publication of my paper, my attention has been drawn to various periodicals containing records of juvenile cannibalism in no fewer than six species of raptorial birds, including *Asio flammeus.*—Collingwood Ingram.

Request for Information

The reproductive biology of the cardinal has been under study in this area for six years. I wish now to compare local data with data from elsewhere in the species' range. For this purpose I am soliciting information on extreme dates of nesting, frequency of nests in different months, clutch-size with dates, nesting sites, extent of cover available for first nests. Details of the study will be supplied to anyone interested in assisting me.—D. M. Scott, *Department of Zoology, University of Western Ontario, London, Ontario, Canada.*

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